NASA/CR-2000-209706

Small Engine Technology (SET) - Task 13 ANOPP Noise Prediction for Small Engines

Jet Noise Prediction Module, Wing Shielding Module, and System Studies Results

Lysbeth Lieber
AlliedSignal Engines and Systems, Phoenix, Arizona
A Unit of AlliedSignal Aerospace Company

September 2000

The NASA STI Program Office ... in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program Office plays a key part in helping NASA maintain this important role.

The NASA STI Program Office is operated by Langley Research Center, the lead center for NASA's scientific and technical information. The NASA STI Program Office provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Program Office is also NASA's institutional mechanism for disseminating the results of its research and development activities. These results are published by NASA in the NASA STI Report Series, which includes the following report types:

- TECHNICAL PUBLICATION. Reports of completed research or a major significant phase of research that present the results of NASA programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA counterpart of peer-reviewed formal professional papers, but having less stringent limitations on manuscript length and extent of graphic presentations.

- TECHNICAL MEMORANDUM. Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.

- CONTRACTOR REPORT. Scientific and technical findings by NASA-sponsored contractors and grantees.

- CONFERENCE PUBLICATION. Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or co-sponsored by NASA.

- SPECIAL PUBLICATION. Scientific, technical, or historical information from NASA programs, projects, and missions, often concerned with subjects having substantial public interest.

- TECHNICAL TRANSLATION. English-language translations of foreign scientific and technical material pertinent to NASA's mission.

Specialized services that complement the STI Program Office's diverse offerings include creating custom thesauri, building customized databases, organizing and publishing research results ... even providing videos.

For more information about the NASA STI Program Office, see the following:

- Access the NASA STI Program Home Page at ***http://www.sti.nasa.gov***

- E-mail your question via the Internet to help@sti.nasa.gov

- Fax your question to the NASA STI Help Desk at (301) 621-0134

- Phone the NASA STI Help Desk at (301) 621-0390

- Write to:
  NASA STI Help Desk
  NASA Center for AeroSpace Information
  7121 Standard Drive
  Hanover, MD 21076-1320

NASA/CR-2000-209706

Small Engine Technology (SET) - Task 13 ANOPP Noise Prediction for Small Engines

Jet Noise Prediction Module, Wing Shielding Module, and System Studies Results

Lysbeth Lieber
AlliedSignal Engines and Systems, Phoenix, Arizona
A Unit of AlliedSignal Aerospace Company

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23681-2199

Prepared for Langley Research Center
under Contract NAS3-27483, Task 13

September 2000

Acknowledgments

The research reported herein was performed by AlliedSignal Engines and Systems, Phoenix, Arizona, and was sponsored by the National Aeronautics and Space Administration (NASA) Langley Research Center, Hampton, Virginia 23681-0001, under the NASA Glenn Research Center Small Engines Technology (SET) Program, Contract No. NAS3-27483, Task Order 13. Mr. Robert A. Golub, NASA Langley Research Center, was the NASA Task Monitor.

Available from:

NASA Center for AeroSpace Information (CASI)
7121 Standard Drive
Hanover, MD 21076-1320
(301) 621-0390

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161-2171
(703) 605-6000

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT)

LIST OF FIGURES AND TABLES

LIST OF FIGURES AND TABLES (CONT)

SMALL ENGINE TECHNOLOGY (SET) - TASK 13
ANOPP NOISE PREDICTION FOR SMALL ENGINES

FINAL REPORT

(Contract No. NAS3-27483, Task Order 13)

<u>Prepared by:</u>

AlliedSignal Engines and Systems
111 S. 34th Street
Phoenix, AZ 85072-2181

1. INTRODUCTION AND BACKGROUND

1.1 Introduction

This Final Report has been prepared by AlliedSignal Engines and Systems, Phoenix, Arizona, a division of AlliedSignal Aerospace, documenting work performed during the period May 1997 through June 1999 for the National Aeronautics and Space Administration (NASA) Glenn Research Center, Cleveland, Ohio, under the Small Engines Technology Program, Contract No. NAS3-27483, Task Order 13, ANOPP Noise Prediction for Small Engines. The NASA Task Monitor was Mr. Robert A. Golub, NASA Langley Research Center, Mail Code 461, Hampton, Virginia 23681-0001; telephone: (757) 864-5281. The NASA Contract Officer was Ms. Linda M. Kendrick, NASA Glenn Research Center, Mail Code 500-305, Cleveland, Ohio 44135-3191; telephone: (216) 433-2407.

The work performed under Task 13 consisted of implementation of improvements in the NASA Aircraft Noise Prediction Program (ANOPP), specifically targeted to noise modeling for small turbofan engines.

1.2 Background

The primary function of the ANOPP program[(1,2)*] is to provide the best, currently-available methods to predict aircraft noise. As new methods and engine acoustic data become available, ANOPP prediction modules can be improved or new modules can be added.

A multi-year effort has been underway to improve the accuracy of ANOPP, as applied to source noise modeling for small turbofan engines. In the initial part of this effort, improvements

---

[*] References noted in parentheses ( ) are listed in Section 6.0.

were implemented in the ANOPP program's ability to predict fan noise[3], as well as core, turbine, and jet noise[4,5].

This report focuses on application of a modified version of the previously-developed semi-empirical procedure for jet noise prediction[5], development of an improved procedure to predict the effects of wing shielding on fan inlet noise, and system studies of the benefits of new noise technology on business and regional aircraft.

1.3 Objectives

The objective of this task was to implement improvements in the ANOPP program, focusing in particular on revisions that would enhance system noise prediction capability for smaller regional transport and business aircraft. Seven subtasks were identified for Task 13, including:

1. **Modification of the combustion, turbine, and jet noise models**: Modifications shall be developed to the current combustion, turbine, and jet noise procedures in ANOPP, based on the results of recent Engines and Systems validation efforts of component noise predictions under Contract No. NAS1-201012, Task 6[4].

2. **Implementation of a semi-empirical procedure for jet noise prediction**: The jet noise prediction procedure outlined in NASA TP-2084[6] shall be implemented in ANOPP. Elements from the earlier General Noise Prediction (GNP) module will be used as is reasonable.

3. **Documentation and reporting**: Documentation of the new ANOPP software and final report generation.

4. **Application of the semi-empirical procedure for jet noise prediction**: The jet noise prediction procedure outlined in NASA TP-2084[6], previously implemented in ANOPP, shall be applied to the Engines and Systems jet noise database to produce a new prediction method. Comparisons with full-scale engine data and the SGLJET and STNJET predictions shall be performed to evaluate the new method.

5. **Development of a procedure to predict the effects of wing shielding**: Analyses presented in NASA CR-168050[7] showed the importance of wing shielding in predicting flyover noise of aircraft with aft-mounted engines. A method shall be developed and implemented in ANOPP to model wing shielding based on Fresnel diffraction theory.

6. **System studies of the benefits of the new noise technology on business and regional aircraft**: Using the improved prediction methods developed in ANOPP for small engines, system studies shall be made to assess the benefits of the noise technologies developed in the NASA AST Noise Reduction programs on business and regional aircraft. FAA certification levels and community exposure noise contours shall be generated for no less than five aircraft configurations based on discussions with NASA Langley.

7. **<u>Documentation and reporting of Subtasks 4 through 6</u>**: Documentation of the new ANOPP software will be generated, as well as a final report.

Tasks 1-3 were documented in Reference (5).

1.4 Summary

1.4.1 Subtask 4: Application of the Semi-Empirical Procedure for Jet Noise Prediction

Jet noise prediction accuracy for small turbofan engines was improved in the ANOPP program, through the installation of a semi-empirical procedure, which used the Engines and Systems jet noise database. The method employed a cubic-spline least-squares procedure to represent the data from the database as a set of interpolation coefficients for normalized directivity, normalized power spectrum, and normalized relative spectrum functions at specific engine operating points, for a number of small turbofan engines.

Regression analyses were then performed for the combined set of engines to obtain curve fits for the interpolation coefficient data as functions of engine operating conditions. The coefficients resulting from the curve fit operation were then implemented in empirical prediction equations in ANOPP, to provide an improved procedure for the prediction of jet noise. The method was compared with the SGLJET and STNJET jet noise prediction models in ANOPP, and was found to yield better agreement with data for small turbofan engines.

1.4.2 Subtask 5: Development of a Procedure to Predict the Effects of Wing Shielding

A wing-shielding model was successfully developed and installed in the ANOPP program, to represent the attenuation caused by the aircraft wing acting as a finite barrier to engine inlet noise. The model was based on Fresnel diffraction theory for a semi-infinite barrier, with modifications to treat the finite barrier presented by the aircraft wing.

Preliminary wing shielding studies performed using the Raynoise ray-tracing program showed the importance of modeling the wing trailing edge as a diffraction edge for aircraft configurations with aft-mounted engines. As a result, the wing-shielding model for ANOPP included the wing leading and trailing edges, as well as the wing tip, as diffraction edges.

Initially, the method was implemented in the GASP program, and was demonstrated with three aircraft configurations. As expected, use of the wing-shielding module attenuated the fan inlet noise, and as a result, the overall aircraft noise, relative to the unshielded case. The model was then installed in the ANOPP program, and the 1992 Baseline Technology business jet was analyzed to obtain predicted attenuation due to the wing shielding effects.

1.4.3 Subtask 6: System Studies of the Benefits of the New Noise Technology on Business and Regional Aircraft

Subtask 6 included multiple activities related to system studies of the benefits of new noise technology on business and regional aircraft.

An update of the 1992 Baseline Technology Study for Business Jet Aircraft was performed to account for improvements in the GASP program. Following this update, system studies were performed for multiple configurations to determine the overall engine noise reduction due to reductions in fan and jet noise, with combustor and turbine noise levels held constant. In addition, to assess the benefits of the noise technologies developed in the NASA AST Noise Reduction programs, the jet noise reduction due to the use of a porous mixer nozzle (developed and tested as part of SET Task 19) was computed and prepared for addition to the ANOPP database.

2. SUBTASK 4: APPLICATION OF THE SEMI-EMPIRICAL PROCEDURE FOR JET NOISE PREDICTION

2.1 Technical Approach

The semi-empirical jet noise prediction procedure is based on an established jet noise measurement database, consisting of arrays of the normalized directivity, the normalized power spectrum, and the normalized relative spectrum functions at specific engine operating points, for a number of small turbofan engines. In order to utilize this information for jet noise predictions in ANOPP, it is necessary to combine the information from each of the engines, and to represent it in a form that allows easy extraction of information at user-specified engine conditions.

The semi-empirical jet noise prediction procedure to accomplish this is shown in Figure 1. For each engine and operating point in the database, the procedure generates cubic-spline least-squares interpolation coefficients to approximate the three functions: normalized directivity, normalized power spectrum, and normalized relative spectrum. Multiple regression analyses are then performed for the combined set of engines to obtain curve fits for the directivity, power spectrum, and relative spectrum interpolation coefficient data as functions of engine operating conditions, such as area ratio, temperature ratio, and pressure ratio. The regression analysis uses the "least squares" method to fit a curve through a set of observations. The coefficients resulting from the curve fit operation are then implemented in empirical prediction equations in the ANOPP program, to provide an improved procedure for the prediction of jet noise.

A preliminary version of the semi-empirical jet noise prediction procedure, developed under the initial phase of Task 13[5], was determined to have a spline overshoot problem. Following analysis of the problem, the current cubic-spline least-squares procedure was developed.

2.2 Cubic-Spline Least-Squares Procedure

A large set of data, the jet noise measurement database, must be represented using a set of coefficients for each of the three functions: normalized directivity, normalized power spectrum, and normalized relative spectrum. The coefficients must be capable of accurately interpolating values for the functions at points other than those in the coefficient table. Additionally, the number of coefficients must be small in order to minimize storage requirements and to minimize the complexity of generating an empirical prediction equation for each of the three functions.

Cubic-spline polynomials are useful for interpolation for a number of reasons. They avoid spurious oscillations associated with interpolation by higher-order polynomials, while providing much better approximations than possible with "straight-line" least-squares fits. Cubic-spline polynomials are guaranteed to pass through the data points in a continuous manner, and have continuous first and second derivatives. However, if cubic-spline interpolation is applied directly to the database, storage requirements increase rather than decrease.

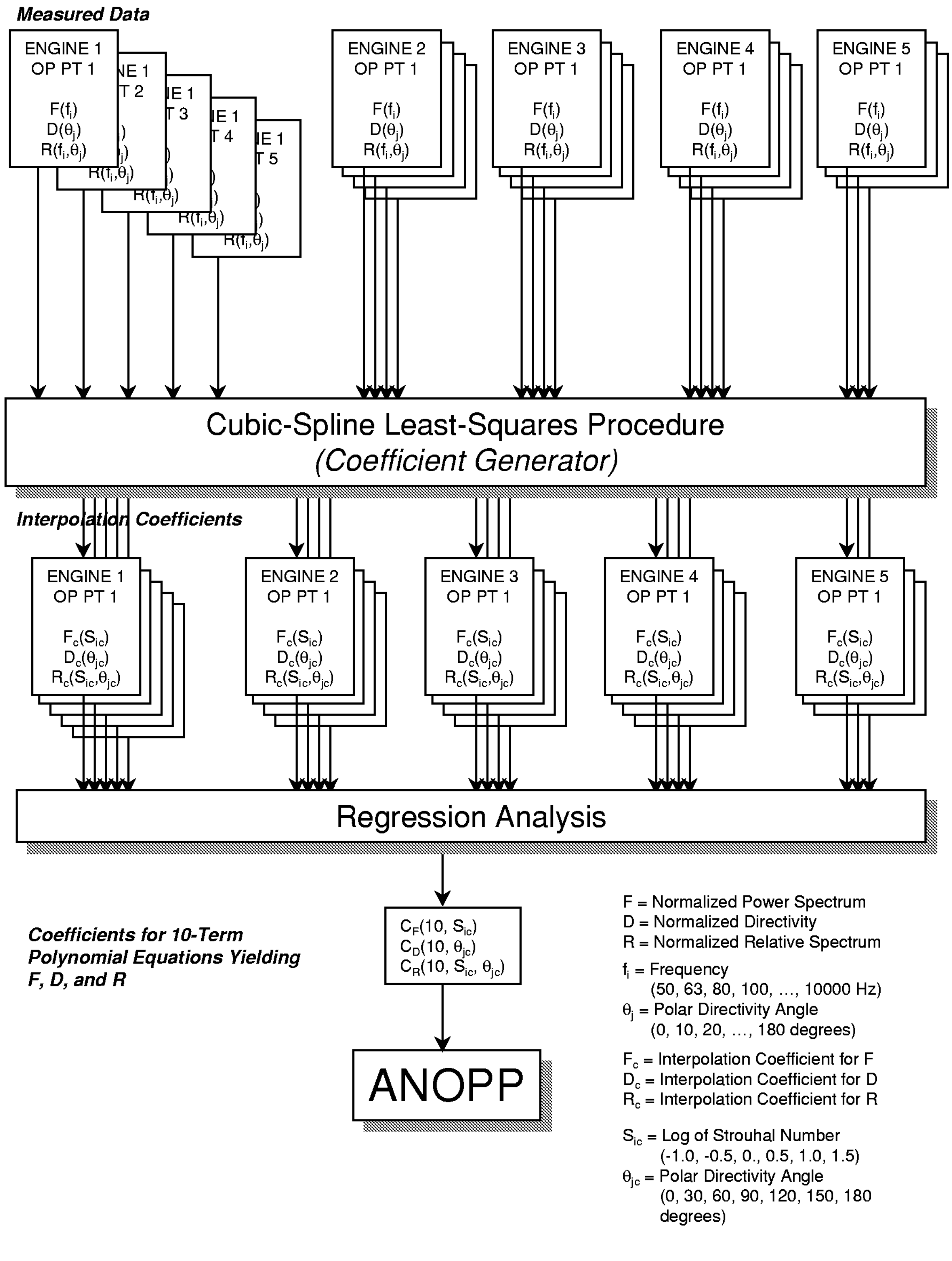


Figure 1. Semi-Empirical Jet Noise Prediction Procedure.

For cubic-spline interpolation of a one-dimensional array of data, say $y_j = y(x_j),\ j = 1, 2, \ldots, N_d$, three values must be stored at each data point: the x_j or node value, the y_j or functional value, and the y''_j or second derivative value. Thus, if the cubic-spline fit is based directly on the N_d data points, the storage requirement is $3N_d$, as compared to the storage requirement of $2N_d$ for the original data. Rather than increasing the amount of data to be stored, it is desired to store some small set of coefficients that adequately represent the function.

If the function to be fit is sufficiently smooth, a smaller number of nodes, say $N << N_d$, can be used, realizing substantial reduction in complexity and storage requirements while retaining the fidelity of the approximation. This can be accomplished by choosing a small number of nodes, or x values, for each function, and then using the least-squares approximation together with the cubic-spline equations to determine a coefficient, or y value, at each node for each function.

An additional benefit is realized by using the least-squares approximation in combination with the cubic-spline equations. Experimental data contains some degree of error or scatter. When cubic-spline interpolation is applied directly to the experimental data points, the scatter is built in to the curve fit. However, the least-squares approximation is a smoothing operation. When combining the least-squares approximation with the cubic-spline equations, the overall effect is that of a “best fit” to the data in the least-squares sense.

To provide additional detail on the prediction technique, cubic-spline interpolation of a one-dimensional array, with known coefficients, $y_j,\ j = 1,2,3,\ldots,N$, will first be discussed. This will be followed by a discussion of how to determine the coefficients with the least-squares approximation, and an overview of how the technique was applied to the jet noise database.

Cubic Spline Interpolation

Given a set of tabulated values y_j, at points x_j, for $j = 1,2,3,\ldots,N$, a cubic-spline interpolating function can be written[8]

$$y(x) = A(x)y_j + B(x)y_{j+1} + C(x)y''_j + D(x)y''_{j+1}, \quad 1 \le j \le N-1 \tag{1}$$

for each interval $x_j \le x \le x_{j+1}$, where the values y''_j are determined by the procedure described below, and the interpolating polynomials are given by:

$$\left.\begin{aligned} A(x) \equiv \frac{x_{j+1} - x}{x_{j+1} - x_j}, \quad B(x) \equiv 1 - A = \frac{x - x_j}{x_{j+1} - x_j} \\ C(x) \equiv \tfrac{1}{6}(A^3 - A)(x_{j+1} - x_j)^2, \quad \text{and} \quad D(x) \equiv \tfrac{1}{6}(B^3 - B)(x_{j+1} - x_j)^2 \end{aligned}\right\} \tag{2}$$

The form of Equation (1) guarantees that the function, $y(x)$, and its second derivative, $y''(x)$, are continuous across the boundaries between intervals (x_{j-1}, x_j) and (x_j, x_{j+1}). However, first derivative continuity is also required across interior boundaries. Differentiating (1) yields

$$\frac{dy}{dx} = \frac{y_{j+1} - y_j}{x_{j+1} - x_j} - \frac{3A^2 - 1}{6}(x_{j+1} - x_j)y_j'' + \frac{3B^2 - 1}{6}(x_{j+1} - x_j)y_{j+1}'' \qquad (3)$$

for the interval $x_j \le x \le x_{j+1}$. First derivative continuity is satisfied across interior boundaries by setting $x = x_j$ in (3) and equating it to the corresponding expression for the interval $x_{j-1} \le x \le x_j$ evaluated at x_j,

$$\frac{x_j - x_{j-1}}{6} y_{j-1}'' + \frac{x_{j+1} - x_{j-1}}{3} y_j'' + \frac{x_{j+1} - x_j}{6} y_{j+1}'' = \frac{y_{j+1} - y_j}{x_{j+1} - x_j} - \frac{y_j - y_{j-1}}{x_j - x_{j-1}}. \qquad (4)$$

This process yields a linear system of $(N-2)$ equations in the unknowns y_j'', $j = 2, \ldots, N-1$. For a unique solution, two more conditions must be specified. These will be taken as boundary conditions at x_1 and x_N. For the normalized power spectrum function, both y_1'' and y_N'' are set equal to zero. For the normalized directivity function, two additional equations are obtained by setting (3) equal to zero at x_1 and x_N.

The complete system of N equations in the N unknowns $y_j'', j = 1, \ldots, N$ can be expressed in matrix notation as

$$\mathbf{E}\mathbf{y}'' = \mathbf{F}\mathbf{y} \qquad (5)$$

Since the matrix $\mathbf{E}$ is strictly diagonally dominant, it is nonsingular, and therefore guaranteed to have an inverse. Thus, the solution of the system (5), assuming the coefficients y_j, $j = 1, \ldots, N$ are known, is

$$\mathbf{y}'' = \mathbf{E}^{-1}\mathbf{F}\mathbf{y}. \qquad (6)$$

Least Squares Approximation

In the cubic-spline formulation of the previous section we assumed that the y_js were already known, and found an expression, Equation (6), for y_j'' in terms of the y_js. Now, instead of assuming that the y_js are known, we will use (6) to rewrite the cubic-spline interpolating function (1) in terms of the unknown y_js. With the new expression for the interpolating function we can utilize the experimental data and apply the least-squares equation to solve for the desired interpolation coefficients y_j.

Using (6) to express the y_j'', $j = 1,\ldots,N$ symbolically in terms of the y_j, $j = 1,\ldots,N$, we can rewrite (1) as

$$y(x) = A(x)y_j + B(x)y_{j+1} + C(x)\sum_{k=1}^{N} G_{jk}y_k + D(x)\sum_{k=1}^{N} G_{(j+1)k}y_k, \quad 1 \le j \le N-1 \tag{7}$$

for each interval $x_j \le x \le x_{j+1}$, where G_{jk} is the jkth element of the matrix

$$\mathbf{G} = \mathbf{E}^{-1}\mathbf{F} \tag{8}$$

and N denotes the desired number of cubic-spline nodes, rather than the number of tabulated values to be interpolated. Collecting the y_js, we can write (7) as

$$y(x) = \sum_{k=1}^{N} \left[H(x)\right]_{jk} y_k. \tag{9}$$

Now we can use our tabulated data from the jet-noise measurement database to solve for the coefficients y_k. Letting $d_i = y(x_i)$ denote the experimental data points, and N_d the number of data points, we can write

$$d_i = \sum_{k=1}^{N} \left[H(x_i)\right]_{jk} y_k, \quad 1 \le i \le N_d \tag{10}$$

where j is chosen so that the data point x_i lies in the interval $x_j \le x_i \le x_{j+1}$. In matrix notation Equation (10) is expressed as

$$\mathbf{d} = \mathbf{H}\mathbf{y}. \tag{11}$$

Equation (11) represents an overdetermined system of N_d equations in N unknowns ($N < N_d$). In general, there is no solution to this problem. However, an approximate solution which yields a "best fit" in the least-squares sense can be found. The least-squares solution to (11) is the value of $\mathbf{y}$ which minimizes the norm of the error vector, $\mathbf{e} = \mathbf{d} - \mathbf{H}\mathbf{y}$. Thus, the least-squares solution to (11) is given by[9]

$$\mathbf{y} = \left(\mathbf{H}^T\mathbf{H}\right)^{-1}\mathbf{H}^T\mathbf{d}. \tag{12}$$

Finally, using the interpolation coefficients y_j, equation (7) can be used to interpolate at any x in the range $[x_1, x_N]$.

Application to the Jet Noise Database

The mathematical theory of the cubic-spline least-squares procedure has been applied in the Coefficient Generator program. The Coefficient Generator program has been coded in Visual Basic for Applications (VBA) and implemented in Microsoft Excel v7.0.

The Coefficient Generator program operates on jet noise measurement data files, to produce cubic-spline least-squares interpolation coefficients. Each file in the jet noise database contains a two-dimensional array of sound pressure level (SPL) values that are a function of normalized frequency and angle. The files typically contain 16 angles and 24 frequencies. Additionally, each data file contains one-dimensional arrays of normalized power spectrum data and normalized directivity data. The normalized power spectrum is a function of frequency, and the normalized directivity is a function of angle. Each normalized power spectrum value is obtained by integrating SPL values at fixed frequency with respect to angle, and each normalized directivity value is obtained by integrating SPL values at fixed angle with respect to frequency.

The Coefficient Generator program calculates interpolation coefficients in a one-dimensional fashion. Typically, six nodes are used in representing the functional dependence on frequency, while seven nodes are used in representing the functional dependence on angle. The interpolation coefficients for the power spectrum function are obtained by applying the results of the previous sections directly to the power spectrum array, while the interpolation coefficients for the directivity function are obtained by operating on the directivity array. However, the relative spectrum is a function of two independent variables, frequency and angle, and its coefficients are computed from the two-dimensional table of SPL values. First, SPL data are used to generate sets of coefficients at fixed angle. Then, the newly generated coefficients are used as data to calculate coefficients at fixed frequency. In this way, the one-dimensional theory is applied to a two-dimensional data set.

In the Coefficient Generator program, calculation of the interpolation coefficients is separated into two distinct groups of equations: those related to the cubic-spline calculations, and those related to the least-squares calculations. First, consider the cubic spline calculations. Two cubic splines, one for interpolation over frequency and a second for interpolation over angle, are generated. The boundary conditions for interpolation over frequency are different from the boundary conditions for interpolation over angle. For interpolation over frequency, the boundary conditions are zero curvature at the endpoints, i.e. $y_1'' = 0$ and $y_N'' = 0$. When used together with (4), these boundary equations result in a natural spline. For interpolation over angle, the boundary conditions are zero slope at the endpoints, i.e. $y_1' = 0$ and $y_N' = 0$. The corresponding boundary equations in terms of the y_j'' are obtained by setting (3) equal to zero at x_1:

$$\frac{3A^2-1}{6}(x_2-x_1)^2 y_1'' - \frac{3B^2-1}{6}(x_2-x_1)^2 y_2'' = y_2 - y_1, \tag{13}$$

and by setting (3) equal to zero at x_N:

$$\frac{3A^2-1}{6}(x_N - x_{N-1})^2 y''_{N-1} - \frac{3B^2-1}{6}(x_N - x_{N-1})^2 y''_N = y_N - y_{N-1}. \tag{14}$$

When used together with (4), these boundary equations result in a clamped spline.

Next, consider the least-squares calculations in the Coefficient Generator program. First, the interpolating polynomials (2) are calculated for use in filling the **H** matrix (see Equation (7)), and then the **H** matrix of Equation (9) is filled. Then, the values of $\mathbf{H}^{\mathrm{T}}$, $\mathbf{H}^{\mathrm{T}}\mathbf{H}$, $(\mathbf{H}^{\mathrm{T}}\mathbf{H})^{-1}$, and $\mathbf{H}^{\mathrm{T}}\mathbf{d}$ are calculated for use in determining the $\mathbf{y}$ and $\mathbf{y}''$ coefficient vectors. The calculation of the $\mathbf{y}$ and $\mathbf{y}''$ coefficient vectors is then completed, using Equation (12) to calculate the $\mathbf{y}$ vector. The $\mathbf{y}''$ vector is calculated using Equations (6) and (8) together with the $\mathbf{y}$ vector just calculated.

The $\mathbf{y}$ and $\mathbf{y}''$ vectors are calculated for each of the three functions: normalized directivity, normalized power spectrum, and normalized relative spectrum.

2.3 Regression Analysis

Regression analysis can be used to determine how a single dependent variable is affected by values of one or more independent variables. In the present application, the regression analysis employed a "least squares" method to fit a curve through a set of observations.

Three main parameters were used to determine the quality of the curve fit:

- **The r2 statistic or coefficient of determination**

  The r2 statistic can have a range from 0 to 1 and is an indicator of how well the equation resulting from the regression analysis explains the relationship among the variables. A coefficient of determination greater than 0.9 is considered to show a strong relationship between the independent and dependent variables.

- **The residual sum of squares**

  The residual sum of squares, or the sum of squares due to error, represents the amount of Y variation left unexplained after the independent variables have been used in the regression equation to predict Y. The smaller the residual sum of squares is compared to the total sum of squares, the larger the coefficient of determination.

- **The F statistic**

  The F test can be used to determine whether the regression results occurred by chance. The F critical value can be obtained from a table of F critical values[10] for a certain confidence interval. The F critical value is

$$F_{k,n-k-1,1-\alpha}$$

where k is the number of independent variables, n is the sample size and α is the confidence interval. The larger the calculated F value is compared to the F critical value, the better the curve fit.

Multiple regression analyses were performed, using Microsoft Excel's regression analysis tool, to find good curve fits for the directivity, power spectrum, and relative spectrum data, for five typical small turbofan engines. It was determined that the independent variables which had the greatest influence on these dependent variables were jet area ratio ($Area_{,secondary}/Area_{,primary}$), mixed stream temperature ratio, and mixed stream pressure ratio. In addition, the optimum curve fit was achieved with a 10-term regression analysis. The ten terms included:

$$AR,\ AR^2,\ AR^3,\ TR,\ TR^2,\ TR^3,\ PR,\ PR^2,\ PR^3,\ b$$

where AR is the area ratio, TR is the temperature ratio, PR is the pressure ratio, and b is the constant.

Directivity regression analysis showed values greater than 0.9 for the coefficient of determination along with small residual sum of squares and larger F values compared to the 2.17 F critical value at 95% confidence interval.

Power spectrum regression analysis showed values greater than 0.9 for the coefficient of determination along with small residual sum of squares and fairly large F values. However at S(-1.0) the coefficient of determination was 0.88 with a rather large residual sum of squares compared to the total sum of squares. Though the F value was greater than the F critical value, it was not very much greater compared to F values in the previous cases. Thus at S(-1.0), the regression analysis provided a satisfactory curve.

Relative spectrum regression analysis provided strong relationships among the dependent and independent variables except at R(0,150), R(0.5,150), R(1.5,150), R(0.5,180), and R(2.0,180). The coefficient of determination was still above 0.7, with fairly large residual sum of squares, and F values greater than the F critical value of 2.17.

2.4 Application in the ANOPP Program

The coefficients for the empirical prediction equations obtained from the regression analyses were then installed in the ANOPP program, in the General Noise Prediction module (GNP). The GNP module uses the coefficients in a set of Taylor Series expansions to compute the acoustic power, six nodal values of the power spectrum, seven nodal values of the overall directivity, and forty-two nodal values of the relative spectrum. These nodal values then are used with a cubic spline interpolation technique to generate directivity and spectrum values, which are employed to produce a standard format noise table of mean-square acoustic pressure.

The GNP Theoretical Manual is included in Appendix I of this report. The GNP User's Manual is contained in Appendix II, and the GNP Test Case Input and Output are in Appendix III.

2.5 Results

The performance of the semi-empirical jet noise prediction method was validated in ANOPP by computing the jet noise using the GNP module and comparing the results with full-scale engine data for the five small turbofan engines used in the generation of the coefficients for the empirical prediction equations.

In addition, the GNP predictions were compared with results from the SGLJET and STNJET modules in ANOPP. The Single Stream Circular Jet Noise (SGLJET) module predicts the single stream jet mixing noise from shock-free circular nozzles. The method is based on SAE ARP 876(11). The method employs empirical data tabulated in terms of relevant dimensionless groups to produce sound spectra as a function of frequency and polar directivity angle. The Stone Jet Noise (STNJET) module, using a method developed by J.R. Stone(12, 13), predicts the far-field mean-square acoustic pressure for single stream and coaxial circular jets. Both jet mixing noise and shock-turbulence interaction noise are included in the model. Both of these jet noise models are described in detail in the ANOPP Theoretical Manual(1). In addition, both the Single Stream Circular Jet and the Stone Jet models have been tailored to the small engine database. This modification has been identified as "Method 2" in ANOPP, to distinguish it from the "Method 1" models targeted to large turbofan engines.

The new GNP predictions of jet noise were compared with measured data and the SGLJET and STNJET methods for five typical small turbofan engines. Comparisons were made at both takeoff and approach conditions. Distributions of jet noise SPL versus 1/3 octave band frequency were plotted at directivity angles of 50, 100, and 150 degrees. In addition, jet noise overall SPL was plotted versus directivity angle for each case. Comparison plots are presented in Figures 2 through 11. The semi-empirical jet noise prediction method of the GNP module consistently shows better agreement with engine data than do the methods of the SGLJET and STNJET modules.

2.6 Conclusions

Application of the semi-empirical jet noise prediction method in the ANOPP program provides a much higher level of accuracy in the prediction of jet noise by directly employing measured data for typical small turbofan engines. While this method yields good agreement with data currently, and easily surpasses the accuracy of the Single Stream Circular Jet Noise and Stone Jet Noise prediction methods, it also affords the capability of being easily updated, if additional engines are included in the small turbofan engine database.

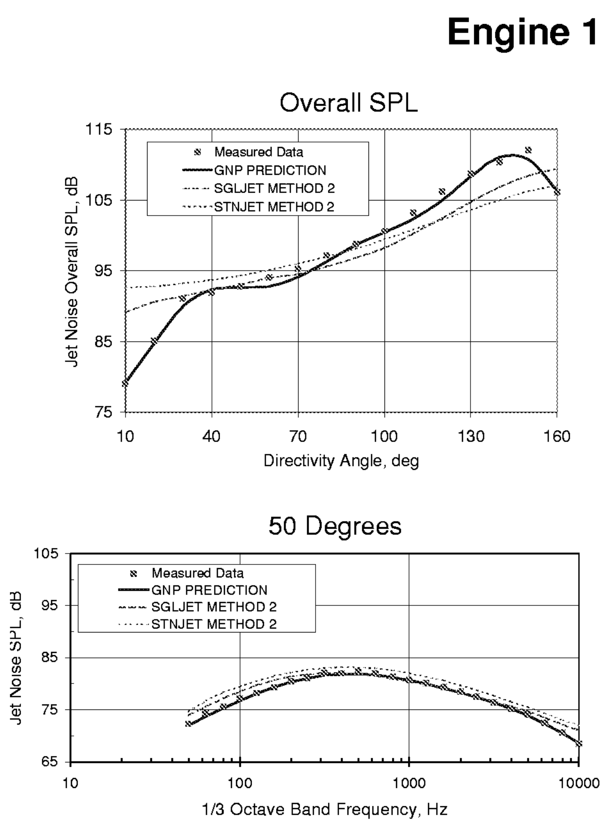


Figure 2. ANOPP Predictions of Jet Noise (GNP, SGLJET, and STNJET Methods) Compared to Measured Data for Engine 1 at Takeoff Conditions.

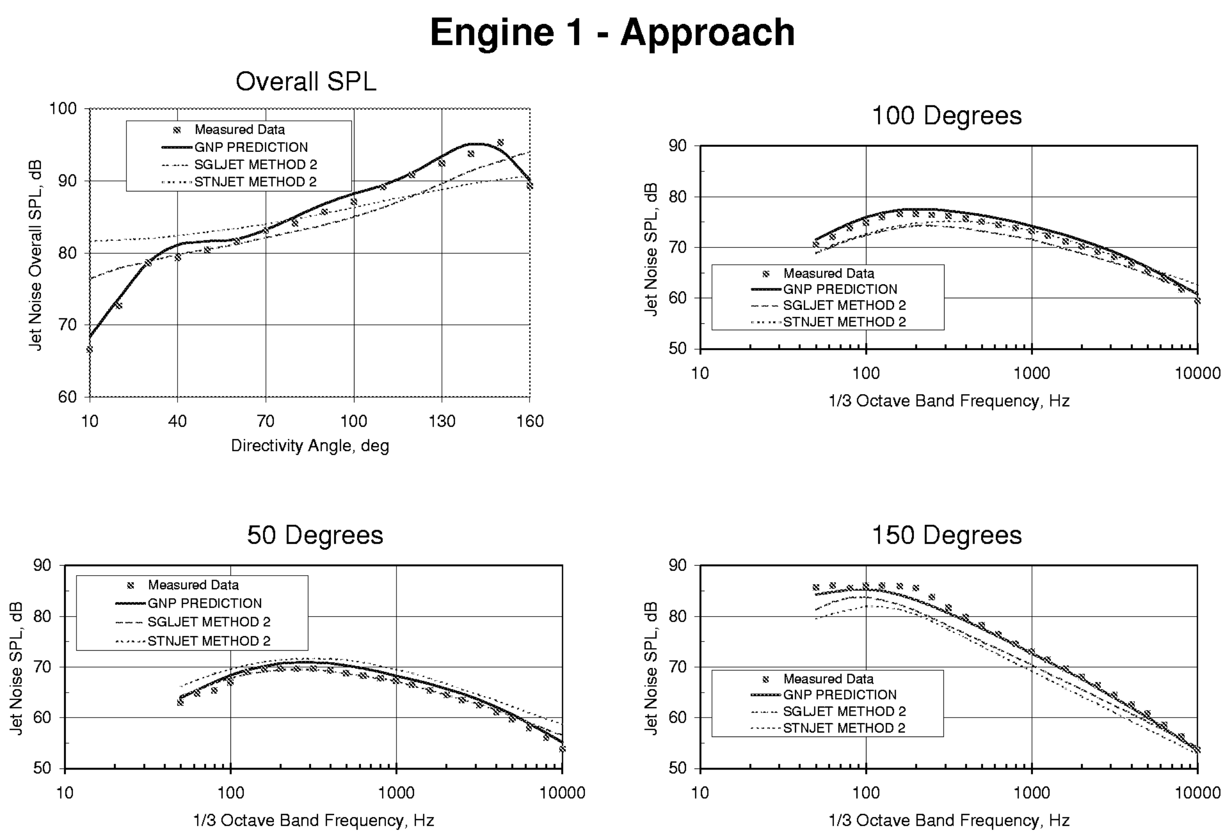


Figure 3. ANOPP Predictions of Jet Noise (GNP, SGLJET, and STNJET Methods) Compared to Measured Data for Engine 1 at Approach Conditions.

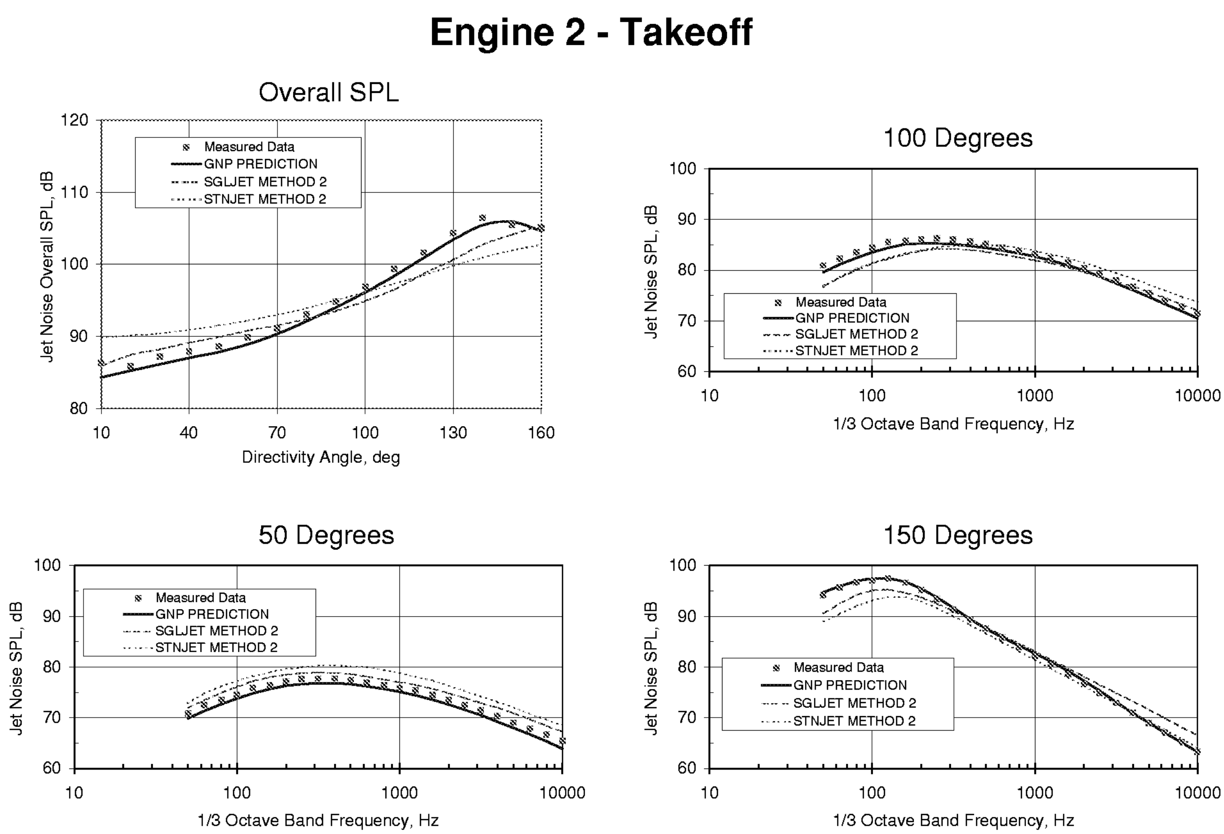


Figure 4. ANOPP Predictions of Jet Noise (GNP, SGLJET, and STNJET Methods) Compared to Measured Data for Engine 2 at Takeoff Conditions.

Engine 2 - Approach

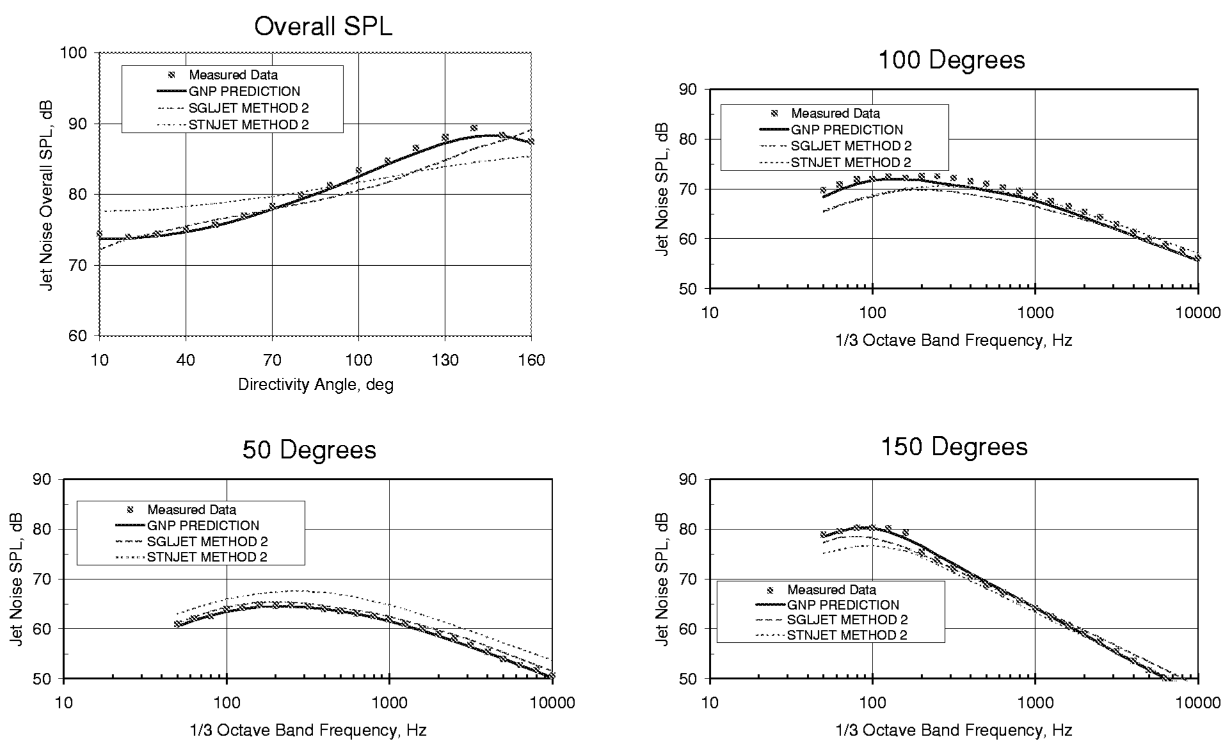


Figure 5. ANOPP Predictions of Jet Noise (GNP, SGLJET, and STNJET Methods) Compared to Measured Data for Engine 2 at Approach Conditions.

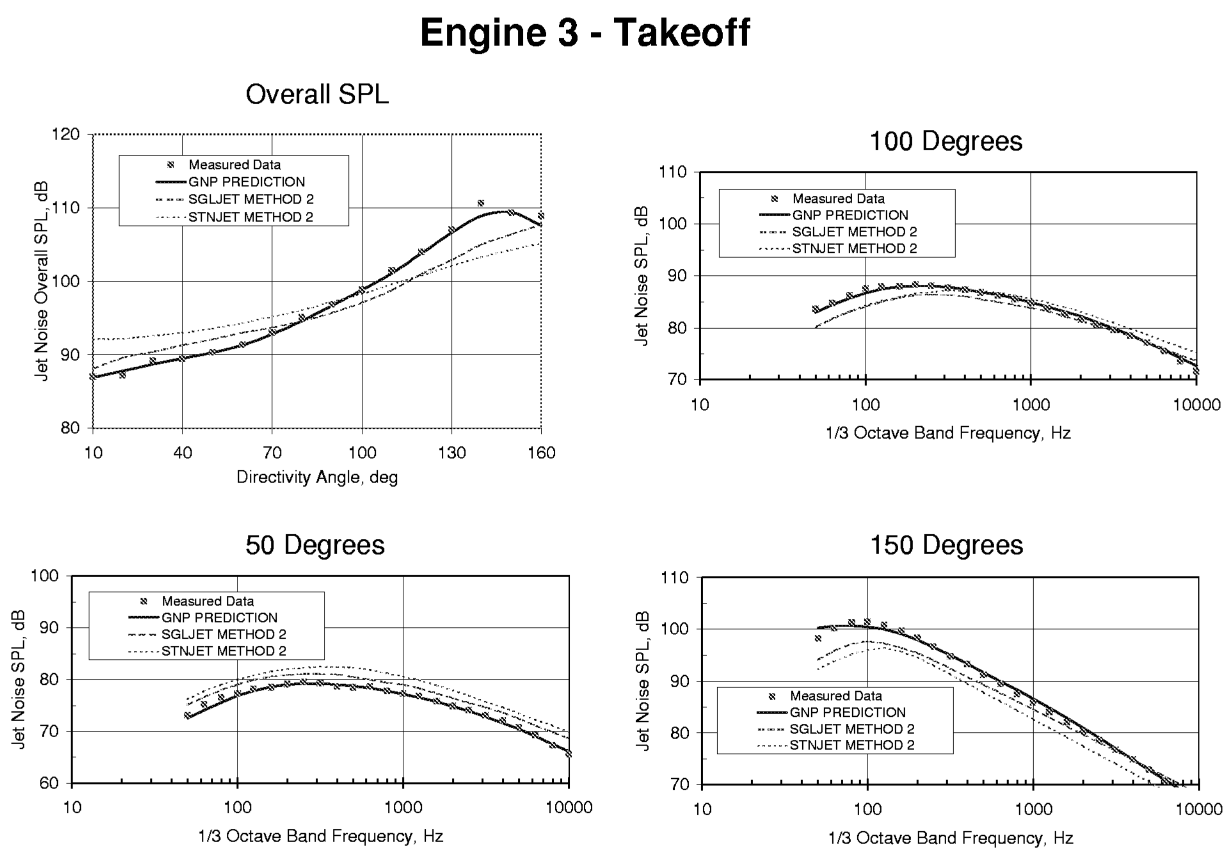


Figure 6. ANOPP Predictions of Jet Noise (GNP, SGLJET, and STNJET Methods) Compared to Measured Data for Engine 3 at Takeoff Conditions.

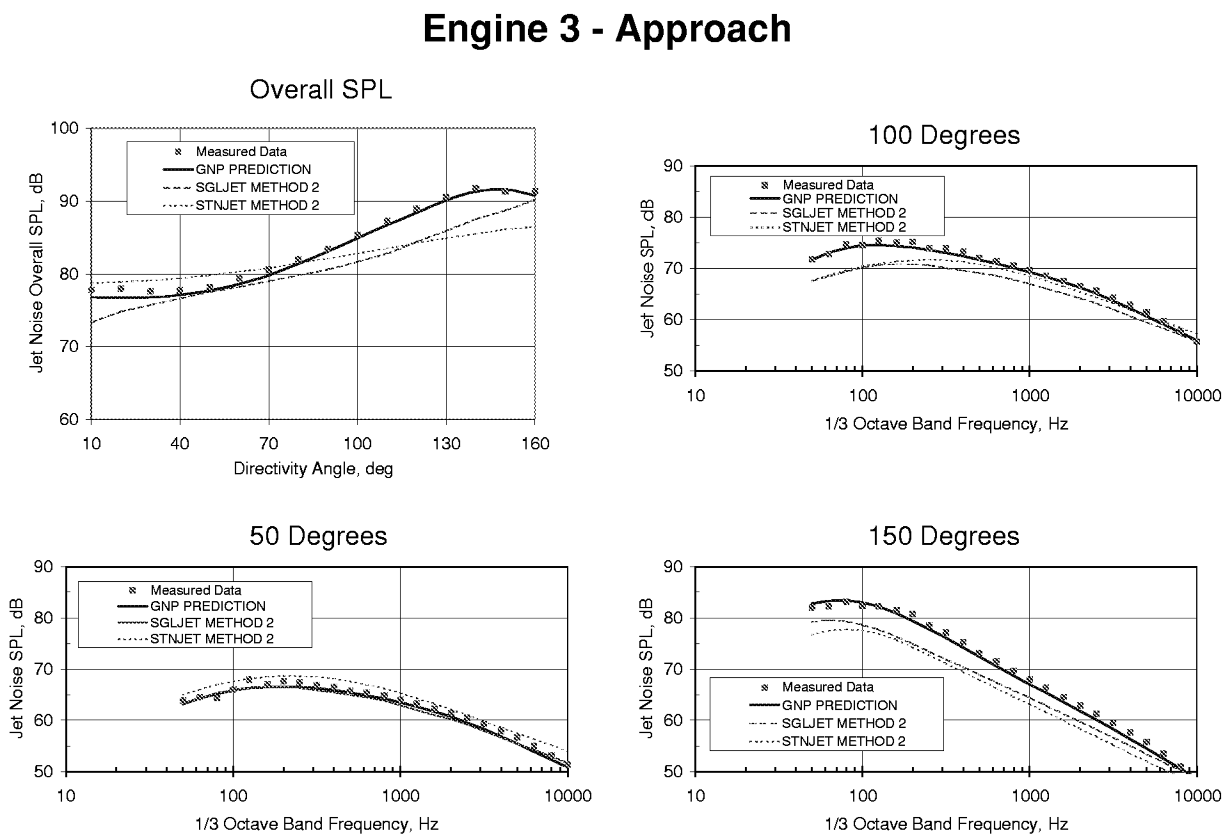


Figure 7. ANOPP Predictions of Jet Noise (GNP, SGLJET, and STNJET Methods) Compared to Measured Data for Engine 3 at Approach Conditions.

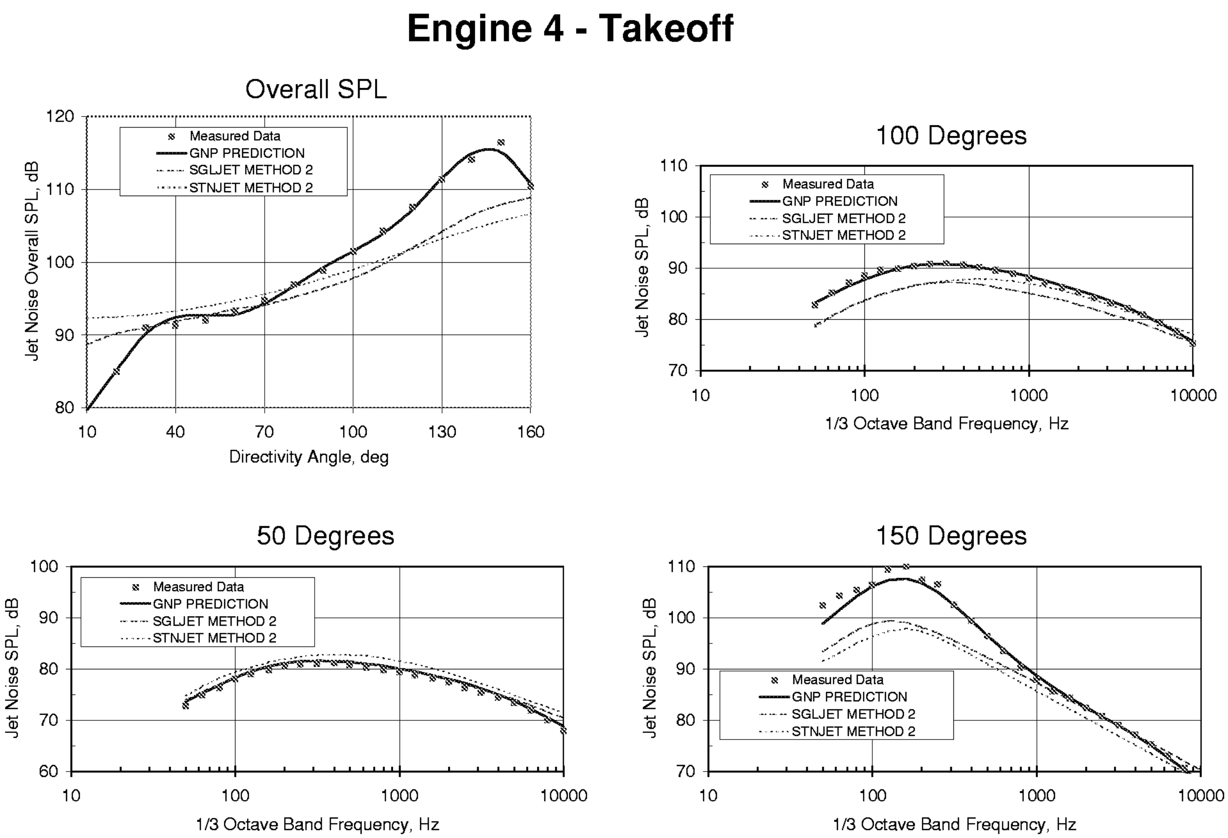


Figure 8. ANOPP Predictions of Jet Noise (GNP, SGLJET, and STNJET Methods) Compared to Measured Data for Engine 4 at Takeoff Conditions.

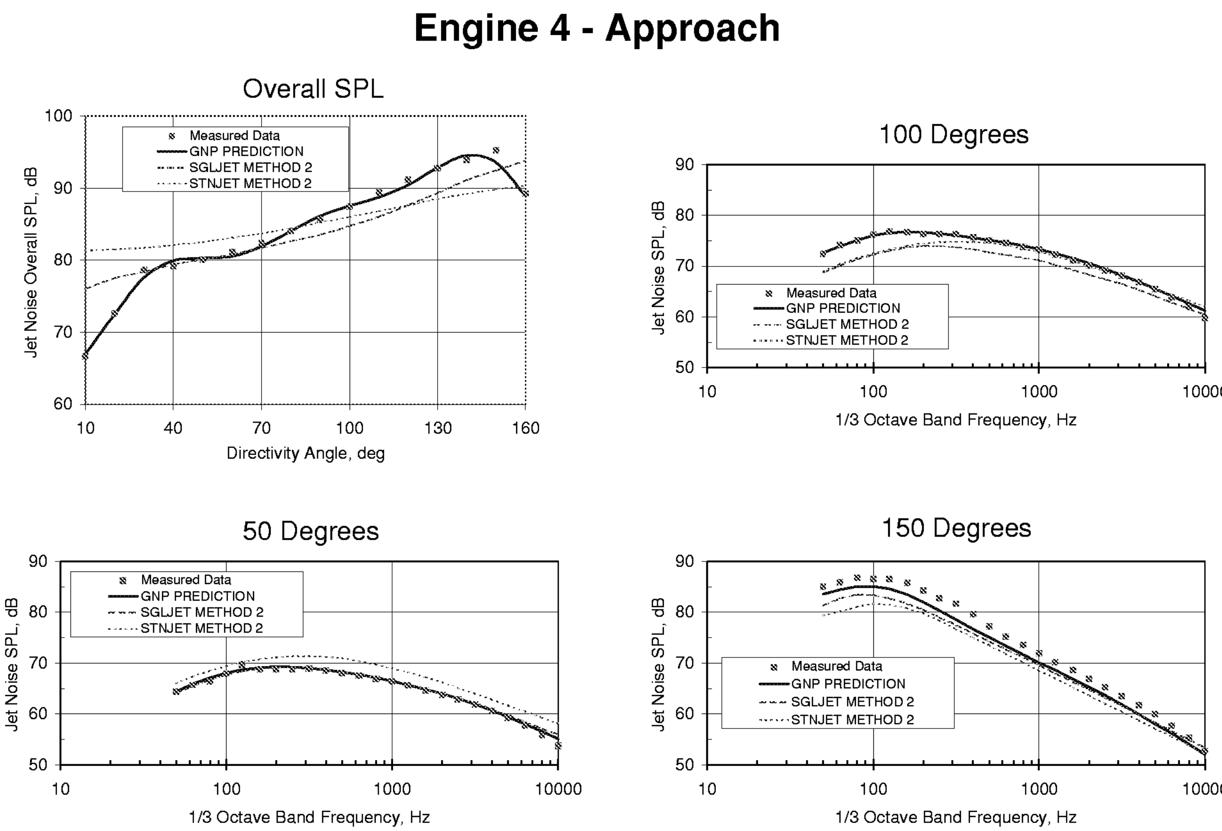


Figure 9. ANOPP Predictions of Jet Noise (GNP, SGLJET, and STNJET Methods) Compared to Measured Data for Engine 4 at Approach Conditions.

Engine 5 - Takeoff

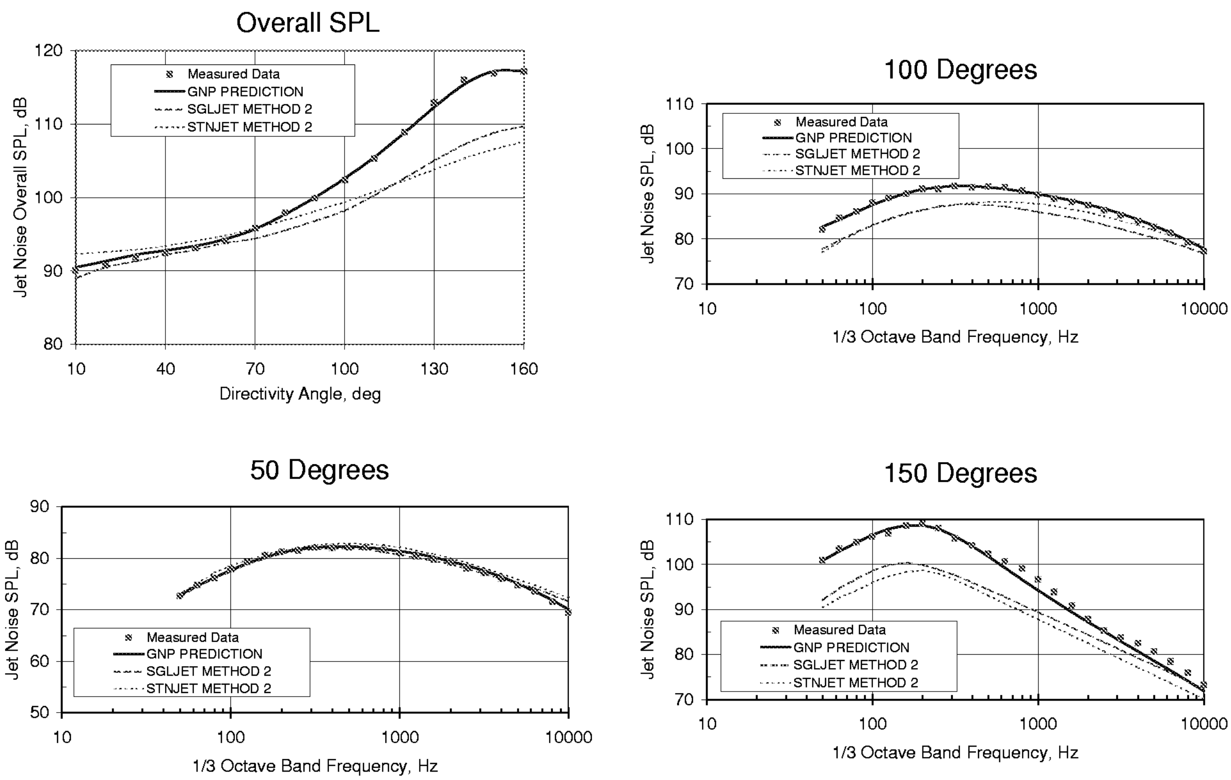


Figure 10. ANOPP Predictions of Jet Noise (GNP, SGLJET, and STNJET Methods) Compared to Measured Data for Engine 5 at Takeoff Conditions.

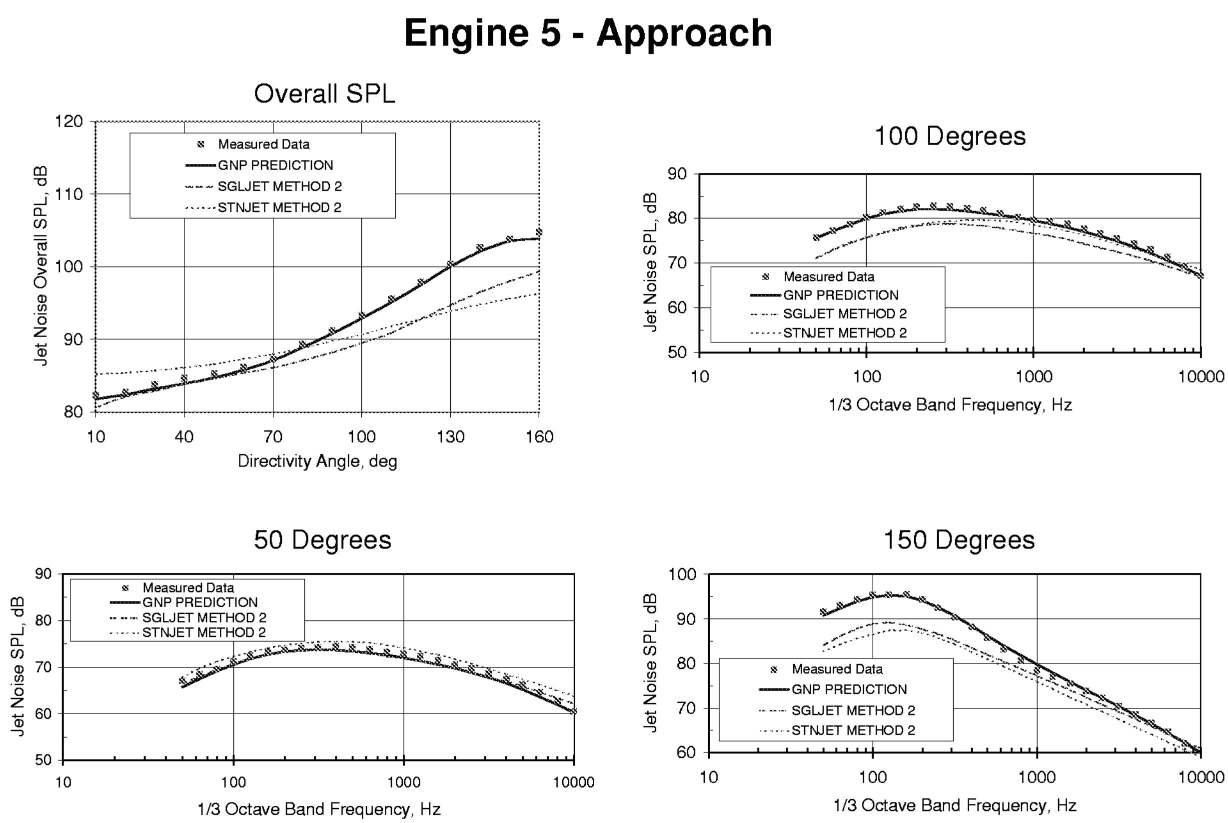


Figure 11. ANOPP Predictions of Jet Noise (GNP, SGLJET, and STNJET Methods) Compared to Measured Data for Engine 5 at Approach Conditions.

3. SUBTASK 5: DEVELOPMENT OF A PROCEDURE TO PREDICT THE EFFECTS OF WING SHIELDING

3.1 Technical Approach

Experimental investigations[14, 15] have shown that wing shielding can have a measurable effect on the attenuation of engine inlet and/or exhaust noise, for certain engine mount configurations. This is an important consideration for noise predictions for business aircraft with aft-mounted engines.

The current version of the ANOPP program does not model wing shielding. In deciding what type of model to employ in ANOPP, the approach used in Engines and Systems' noise prediction program, GASP[7], was considered first. The simple wing-shielding model for fan inlet noise in the current version of GASP treats only the leading edge and wing tip as diffraction edges. This type of model was reasonably valid for older business aircraft configurations in which the engines were mounted on the aft fuselage and the inlets were positioned forward of the wing trailing edge. In such cases, diffraction around the wing trailing edge would not be expected to have a significant influence on wing shielding effects. However, as business aircraft have become larger, many current configurations have aft-mounted engines with inlets positioned aft of the wing trailing edge. This type of configuration demands that the simple wing-shielding model in GASP be reconsidered.

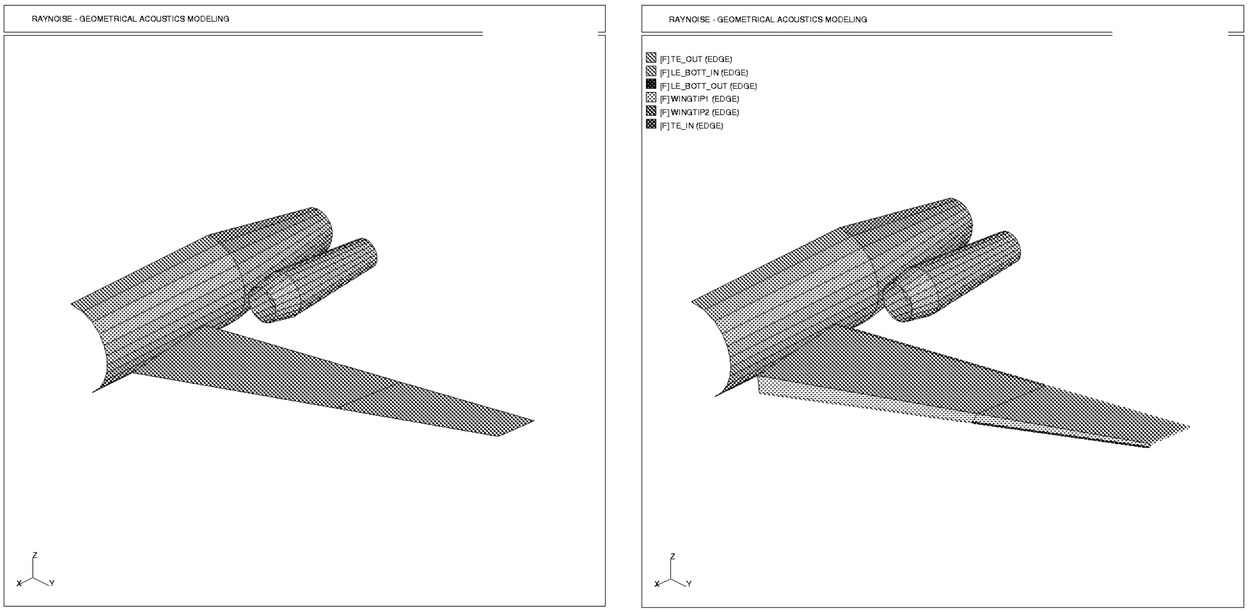
As a first step toward accomplishing this, a study was performed using the Raynoise ray-tracing program to verify the importance of the trailing edge as a diffraction edge in the wing-shielding model. Then, the GASP wing-shielding model was reformulated to treat the leading edge, trailing edge, and wing tip as diffraction edges. In addition, a better definition of the wing geometry was included in the model, to ensure the accuracy of the diffraction edge positions relative to the engine inlet. Once this model had been demonstrated in the GASP program, it was installed in ANOPP, and validation was performed for a typical business aircraft with engines mounted fully aft of the wing trailing edge.

3.2 Wing Shielding Using Ray-Tracing Program

The acoustic ray-tracing code Raynoise[16] from LMS was used to analyze shielding of engine inlet noise by an aircraft wing. Raynoise models the physics of acoustical propagation, including specular and diffuse reflections against physical boundaries, wall absorption and air absorption, diffraction, and transmission through walls. The program utilizes an implementation of Fresnel diffraction theory and allows only first order diffraction (no diffraction around curved surfaces).

Raynoise requires a geometry model, created in an external program, e.g., PATRAN. The model that was used for this study was derived from a generic business jet with a 25-foot wing span. Because the program does not model diffraction around curved surfaces, a simplified

aircraft model was constructed in which the wing was represented by flat plates having approximately the same chord length as the original aircraft wing (Figure 12(a)).



(a)
Original model

(b)
Leading edge modeled as equivalent diffraction edge

Figure 12. The Raynoise Geometry Model for the Generic Business Aircraft Uses Flat Plates to Represent the Wing, Fuselage, and Nacelle.

Diffraction edges can also be defined in the model. Because Raynoise only supports single order diffraction, an approximation must be made in the case where there are multiple barriers. Raynoise uses a technique called equivalent diffraction that assumes the "highest" point above a series of barriers is the primary contributor to diffraction. So, diffraction of multiple barriers is assumed to be nearly equivalent to the effects of diffraction at this single point.

The geometry model was modified to utilize this equivalent diffraction approach on the leading edge of the wing (Figure 12(b)). This new model allowed for the diffraction edge to be the tip of the leading edge of the wing.

Material properties were then assigned to elements within the model. The wing was treated as being completely reflective, and the fuselage and nacelle were modeled as completely absorptive. This eliminated the possibility of reflections from the planar surfaces that approximated the fuselage and nacelle curvature.

The noise source(s) and receiver(s) also needed to be defined. The engine noise source was defined as a point source having sound power of 100 dB across all octave bands. Directivity was not modeled. The noise source was located slightly in front of the engine nacelle. The microphone ground plane was located 1000 feet below the aircraft to simulate actual flyover

altitudes. The 10 dB down point could extend from 30 to 150 degrees from the inlet. Therefore, the ground plane extended 1500 feet forward and aft of the aircraft, and 1500 feet to the side. The 4000 Hz octave band was selected for the analyses.

To obtain a baseline prediction, the wing and fuselage were removed from the Raynoise model, so that the effects of the engine with only nacelle shielding were represented. The results, in terms of sound pressure level (SPL) contours, are shown in Figure 13. Then, for comparison, analyses were performed with the wing and fuselage. Results are shown in Figure14(a) for diffraction edges on the leading edge and wing tip, in order to match the current GASP model. Then, the leading edge and trailing edge as diffraction edges were analyzed, and results are shown in Figure 14(b). This initial set of analyses showed that the use of the trailing edge as a diffraction edge has a substantial impact at locations in front of the aircraft.

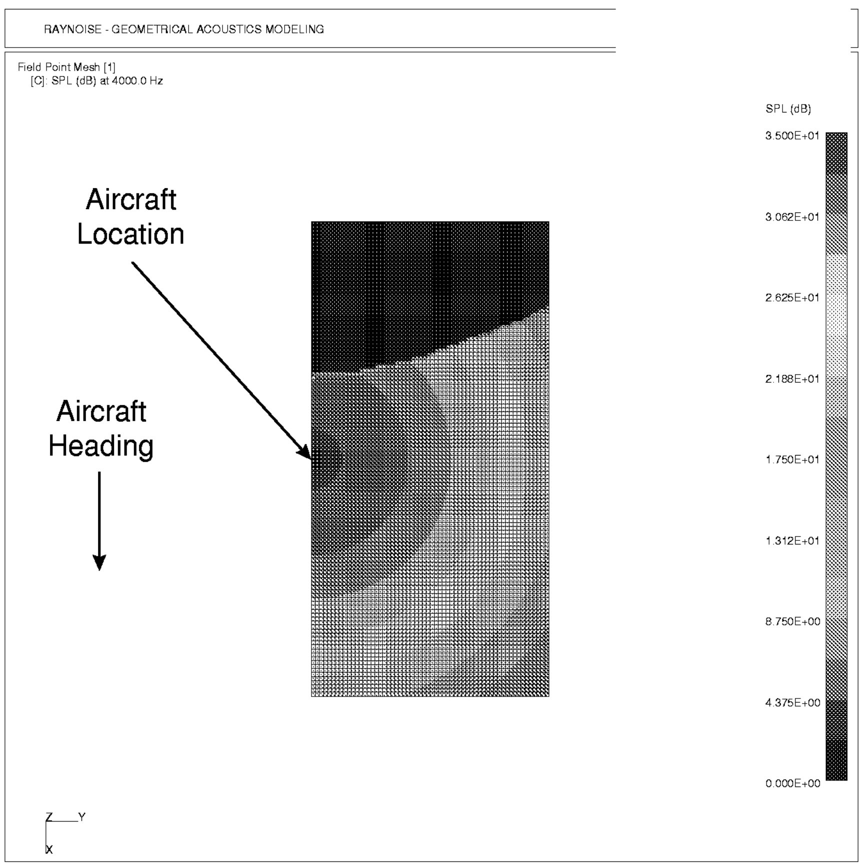
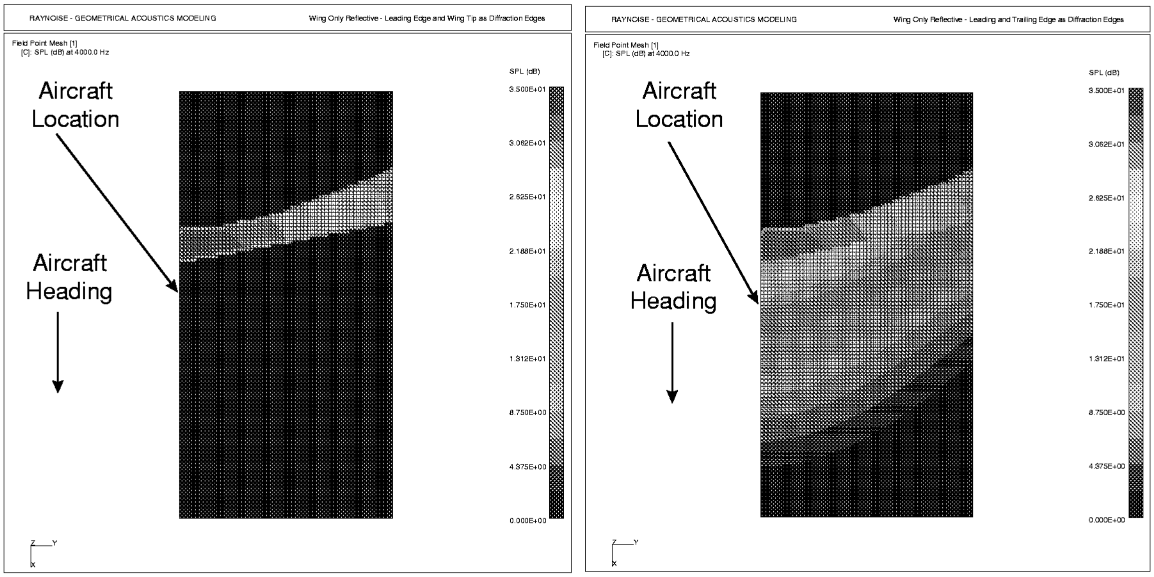


Figure 13. Raynoise Prediction of SPL Contours for the Engine Only, With a Completely Absorptive Nacelle (Wing and Fuselage Removed).

An additional study was performed with and without wing tip diffraction, while maintaining the leading and trailing edges as diffraction edges. This study showed that the wing tip diffraction edge has no impact within the boundaries of the ground plane.



(a)
Leading edge and wing tip as diffraction edges

(b)
Leading edge and trailing edge as diffraction edges

Figure 14. Raynoise Prediction of SPL Contours, With Wing Diffraction Edges.

From the Raynoise studies, it was concluded that diffraction around the wing trailing edge contributes to the noise forward of the aircraft. However, wing tip diffraction does not have a significant impact on the noise area of interest. Therefore, the addition of the trailing edge as a diffraction edge in the wing-shielding model was clearly indicated.

3.3 Description of Wing-Shielding Model for ANOPP

The new wing-shielding model developed for the ANOPP program employs the Fresnel diffraction theory for a semi-infinite barrier, as described in Beranek(17) and Maekawa(18), with modifications to treat the finite barrier presented by the aircraft wing.

The process for computing the attenuation resulting from wing shielding is described in the following paragraphs.

As an initial step, the wing configuration is described in a local coordinate system with the origin positioned at the engine inlet (Point 1), as shown in Figure 15. In the original GASP model, only three dimensions on the wing were specified: the distance from the engine inlet to the leading edge, the distance from the engine inlet to the wing tip, and the distance between the engine inlet and the wing surface. In the new model, it is necessary to define the wing boundaries more accurately. The user must specify the coordinates at the wing root leading edge, root trailing edge, tip leading edge, and tip trailing edge, relative to the location of the engine inlet.

Then, the engine inlet and wing coordinates are transformed into a global coordinate system consistent with the observer location on the ground (Point O). This transformation must take into account the aircraft attitude and position at the particular time of the observation.

Once the coordinates of the critical points in the configuration have been determined, the location of the point representing the intersection of the line between the engine inlet (Point 1) and the observer on the ground (Point O) with the plane of the wing must be computed. Figure 15 illustrates the configuration of line 1-O and the wing plane, with the intersection point (Point I). The coordinates of the intersection point are determined by solving a set of three equations in three unknowns (x_I , y_I , and z_I). Two of the equations are produced by the 2-point form of the equation for the line 1-O:

$$\frac{x_I - x_O}{x_1 - x_O} - \frac{y_I - y_O}{y_1 - y_O} = 0 \tag{15}$$

$$\frac{x_I - x_O}{x_1 - x_O} - \frac{z_I - z_O}{z_1 - z_O} = 0 \tag{16}$$

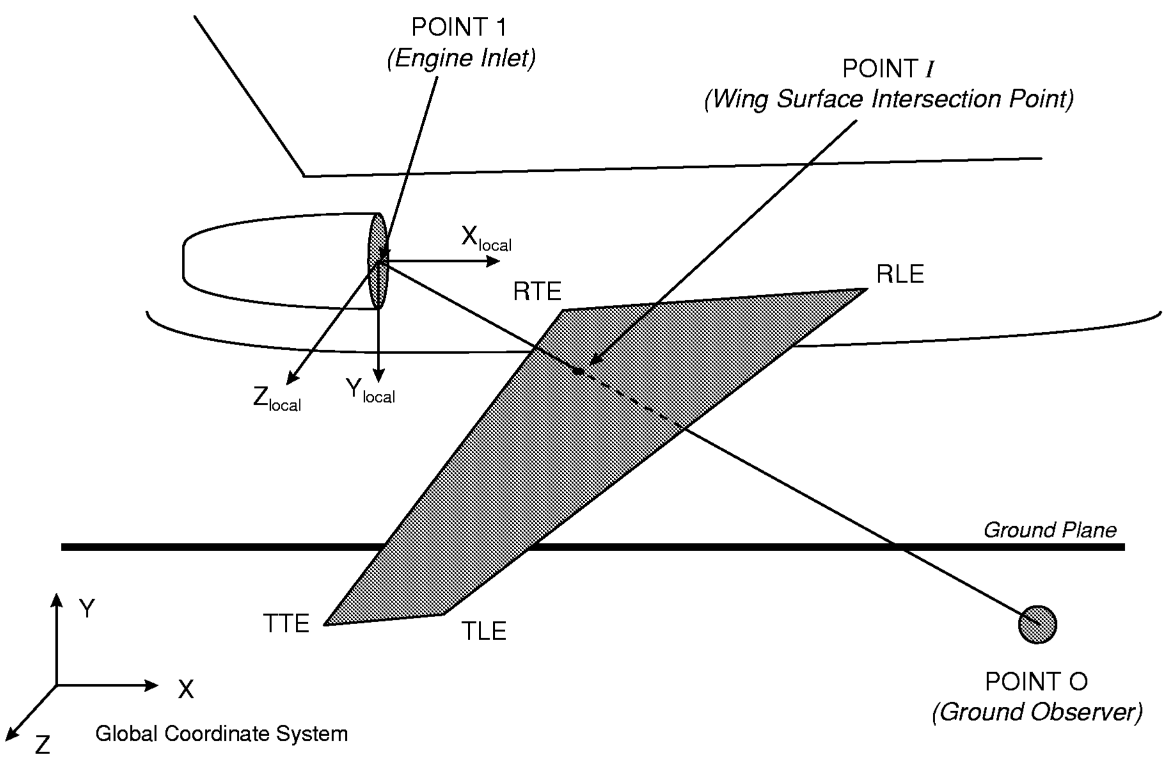


Figure 15. Definition of the Wing-Engine-Observer Configuration with Local and Global Coordinate Systems for the Wing-Shielding Model.

The other equation comes from the 3-point form of the equation for the wing plane:

$$\begin{vmatrix} x_I - x_{RLE} & y_I - y_{RLE} & z_I - z_{RLE} \\ x_{RTE} - x_{RLE} & y_{RTE} - y_{RLE} & z_{RTE} - z_{RLE} \\ x_{TLE} - x_{RLE} & y_{TLE} - y_{RLE} & z_{TLE} - z_{RLE} \end{vmatrix} = 0 \qquad (17)$$

Because four points have been specified to describe the boundaries of the wing, the wing surface may not actually be planar. However, for the purpose of determining the intersection Point I, the assumption is made that the wing plane is described by the points at the root leading and trailing edges, and the tip leading edge. The intersection point (Point I) may or may not be located within the boundaries of the wing surface.

After the intersection Point I has been determined, then the point on each wing boundary which is nearest to Point I must be located, as shown in Figure 16. Each of these points (Points W_{LE}, W_{TE}, and W_{TIP}) is computed by solving a set of three equations in three unknowns (e.g., $x_{W_{LE}}$, $y_{W_{LE}}$, and $z_{W_{LE}}$). The equations are obtained by imposing the following conditions:

1) The line I-W must be perpendicular to the wing boundary. This condition is represented by setting the dot product of the line I-W vector and the wing boundary line vector equal to zero, e.g.:

$$\left(x_I - x_{W_{LE}}\right)\left(x_{RLE} - x_{TLE}\right) + \left(y_I - y_{W_{LE}}\right)\left(y_{RLE} - y_{TLE}\right) + \left(z_I - z_{W_{LE}}\right)\left(z_{RLE} - z_{TLE}\right) = 0 \qquad (18)$$

2) The point W must lie on the wing boundary. This condition is met when the coordinates of the point W satisfy the 2-point equation of the line representing the wing boundary edge, e.g.:

$$\frac{x_{W_{LE}} - x_{RLE}}{x_{TLE} - x_{RLE}} - \frac{y_{W_{LE}} - y_{RLE}}{y_{TLE} - y_{RLE}} = 0 \qquad (19)$$

$$\frac{x_{W_{LE}} - x_{RLE}}{x_{TLE} - x_{RLE}} - \frac{z_{W_{LE}} - z_{RLE}}{z_{TLE} - z_{RLE}} = 0 \qquad (20)$$

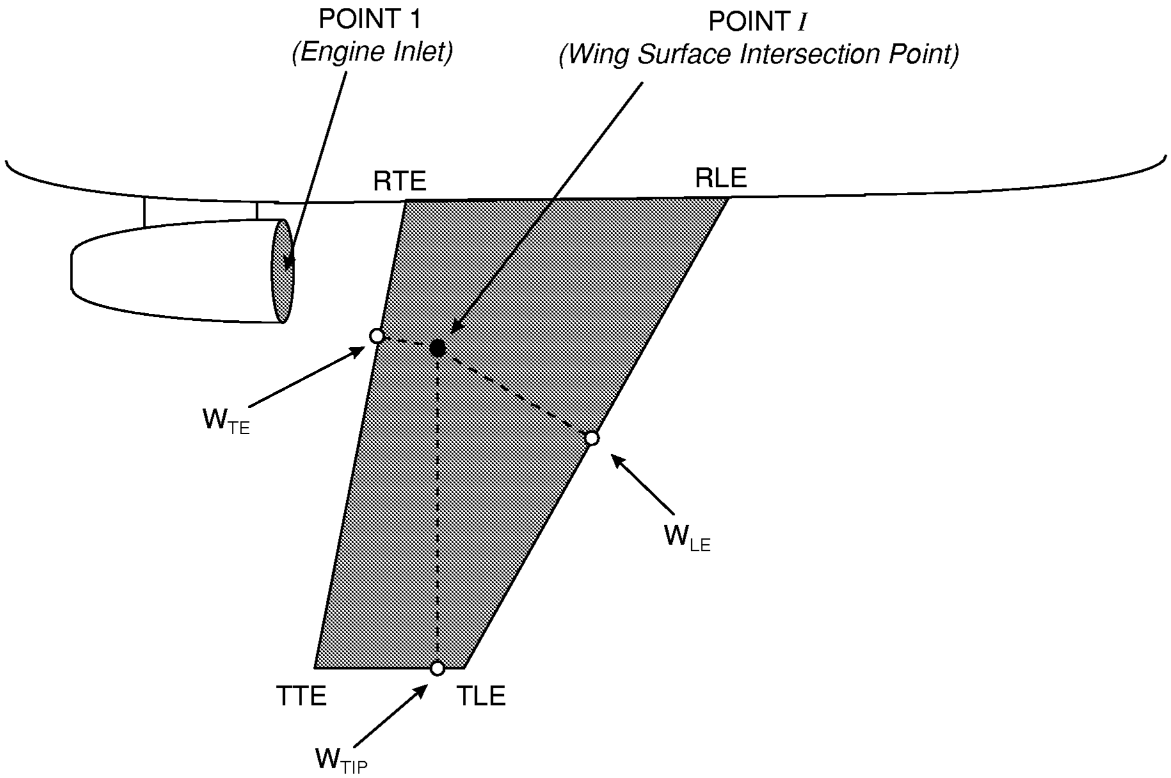


Figure 16. Points W That Are Closest to Point *I* on Each Diffraction Edge (Wing Boundary).

It is necessary then to determine if the intersection point I actually is located within the boundaries of the wing. If it is outside the wing, then no attenuation of the noise source is present. However, if Point I lies on the wing surface, then the Fresnel diffraction theory may be applied to determine the level of attenuation.

Assuming that Point I is located within the boundaries of the wing, then the attenuation of the noise source due to wing shielding must be determined for each diffraction edge (i.e., wing boundary edge). For each diffraction edge, three distances must be computed, as shown in Figure 17:

1) The direct source-receiver path length, from Point 1 to Point O, d_{1O},

2) The distance from Point 1 to the closest point on the diffraction edge, Point W, d_{1W},

3) The distance from the point W on the diffraction edge to the observer location on the ground, Point O, d_{WO}.

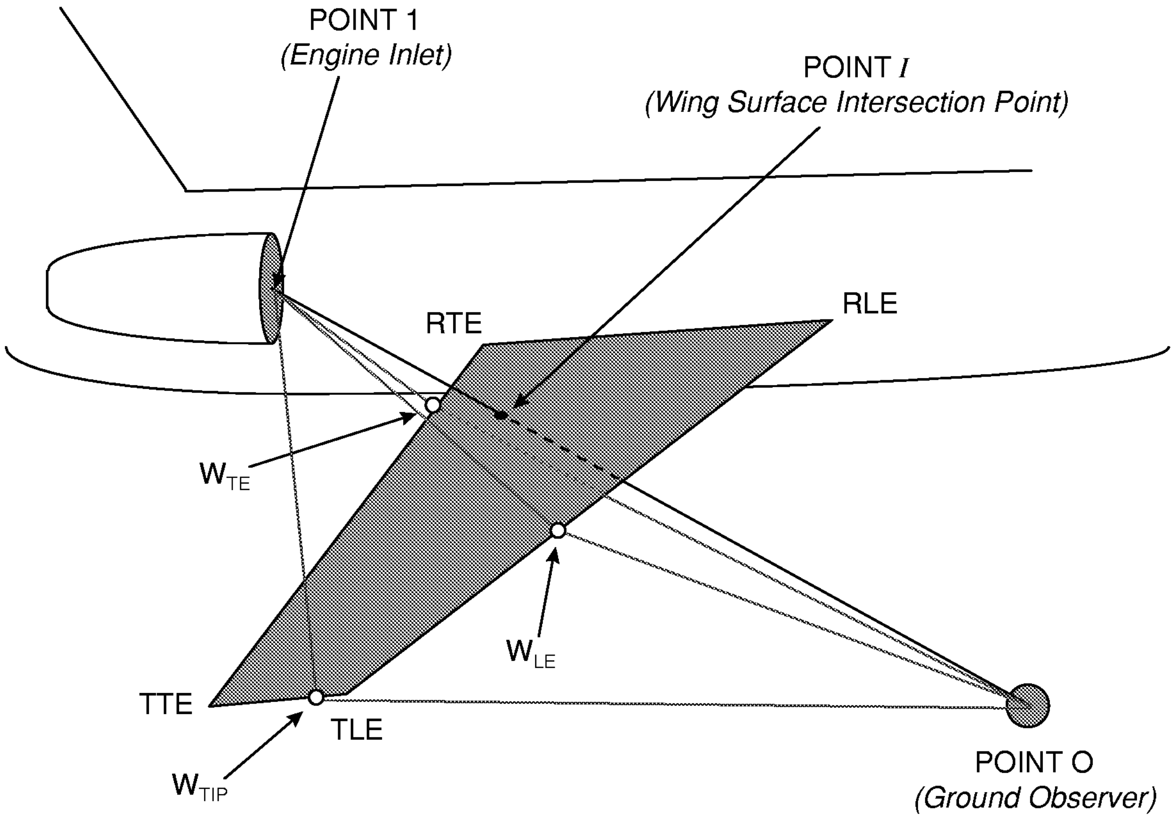


Figure 17. Distances from Source (Point 1) to Receiver (Point O) for Direct Path and Paths Around Diffraction Edges.

From these three distances, the difference in source-receiver path length between the direct and diffracted sound fields may be computed:

$$\delta = (d_{1W} + d_{WO}) - d_{1O} \qquad (21)$$

where $\delta > 0$ when Point *I* lies on the wing surface, $\delta = 0$ when Point *I* lies on the wing boundary edge, and $\delta < 0$ when Point *I* is beyond the wing surface.

From this difference in distances, the Fresnel number is calculated as follows:

$$N = 2\, f_i\, \delta / c \qquad (22)$$

where f_i represents the frequency for each 1/3 octave band, in Hz, and c represents the freestream speed of sound.

The attenuation equation is then computed for each 1/3 octave band frequency as follows:

$$A(f_i) = \begin{cases} 20\ \log \dfrac{\sqrt{2\pi N}}{\tanh\sqrt{2\pi N}} + 5.0 & ; N \geq 0 \\ 20\ \log \dfrac{\sqrt{2\pi|N|}}{\tan\sqrt{2\pi|N|}} + 5.0 & ; \quad -0.2 \leq N < 0 \\ 0. & ; \quad N < -0.2 \end{cases} \tag{23}$$

The attenuation computed in this manner represents noise reduction due to a semi-infinite barrier. In the previous GASP model, the semi-infinite barrier assumption was made, and only the leading edge or wing tip could serve as a diffraction edge at any given time. In the new model, however, diffraction around multiple edges, including the trailing edge, is considered. In order to obtain an equivalent total attenuation from the combined effects of the three diffraction edges, the individual attenuations at any frequency f_i are combined as follows:

$$A_{TOT} = -10\log\sum 10^{-(A_k/10)} \tag{24}$$

where k = LE, TE, TIP.

3.4 Demonstration of the New Model in GASP

In order to demonstrate the new wing-shielding model in GASP, three test cases were considered, representing aircraft configurations with the engine inlets positioned at various locations relative to the trailing edge of the wing. The three configurations considered were:

1) A small business aircraft, with the engine inlets positioned forward of the wing trailing edge.

2) A medium-sized business aircraft, with the engine inlets located at the wing trailing edge.

3) A large business aircraft, with the engine inlets positioned aft of the wing trailing edge.

GASP analyses were performed for each aircraft/engine configuration, in two modes: without wing shielding, and with the new wing-shielding model, using an accurate description of the wing configuration. Predictions were run at approach, cutback takeoff, and sideline conditions. Results from the test cases are shown in Tables 1 through 3. As expected, use of the wing-shielding model attenuated the fan inlet noise, and as a result, the overall aircraft noise, for all three aircraft configurations.

Table 1. GASP Predictions for Aircraft Configuration 1.

SOURCE	With Wing Shielding			No Wing Shielding		
	APP	CUT	SIDE	APP	CUT	SIDE
FAN INLET	**76.5**	**57.4**	**69.4**	**86.5**	**72.2**	**78.9**
TOTAL	**91.1**	**84.8**	**88.2**	**93.2**	**85.1**	**88.9**

Table 2. GASP Predictions for Aircraft Configuration 2.

SOURCE	With Wing Shielding			No Wing Shielding		
	APP	CUT	SIDE	APP	CUT	SIDE
FAN INLET	**71.7**	**60.9**	**72.7**	**85.3**	**70.3**	**80.7**
TOTAL	**89.8**	**80.5**	**89.3**	**91.4**	**80.9**	**90.0**

Table 3. GASP Predictions for Aircraft Configuration 3.

SOURCE	With Wing Shielding			No Wing Shielding		
	APP	CUT	SIDE	APP	CUT	SIDE
FAN INLET	**81.3**	**70.1**	**72.9**	**85.9**	**70.8**	**76.8**
TOTAL	**89.1**	**76.7**	**82.6**	**90.3**	**76.9**	**83.5**

In addition to the tabulated summary of noise levels, plots of tone corrected perceived noise level versus engine observer angle were prepared for both fan inlet and total noise, with and without wing shielding, for Aircraft 1 and 3. These plots are shown in Figures 18 through 23, for approach, cutback takeoff, and sideline conditions. The difference in the two wing-engine configurations is easily seen in the extent of wing shielding predicted for each aircraft. For Aircraft 1, with the engine inlet positioned forward of the wing trailing edge, the wing shielding effects are present at engine observer angles up to 140 degrees (at takeoff). This is indicative of the barrier effect of the wing, as the aircraft passes overhead. In contrast, Aircraft 3 has the engine inlet positioned aft of the trailing edge. Therefore, the barrier effect of the wing provides attenuation over a more restricted range of observer angles, and the fan inlet noise is not attenuated beyond 40 degrees on takeoff, and 80 degrees at sideline conditions.

3.5 Application in the ANOPP Program

After demonstration of the wing-shielding model in the GASP program, the algorithm was then installed in the ANOPP program as the Wing Geometric Effects module, which is accessed with the “EXECUTE WING” command.

The ANOPP Theoretical Manual for the Wing Shielding module is included in Appendix IV of this report. The ANOPP Wing Shielding User’s Manual is contained in Appendix V, and the Wing Shielding Test Case Input and Output are in Appendix VI.

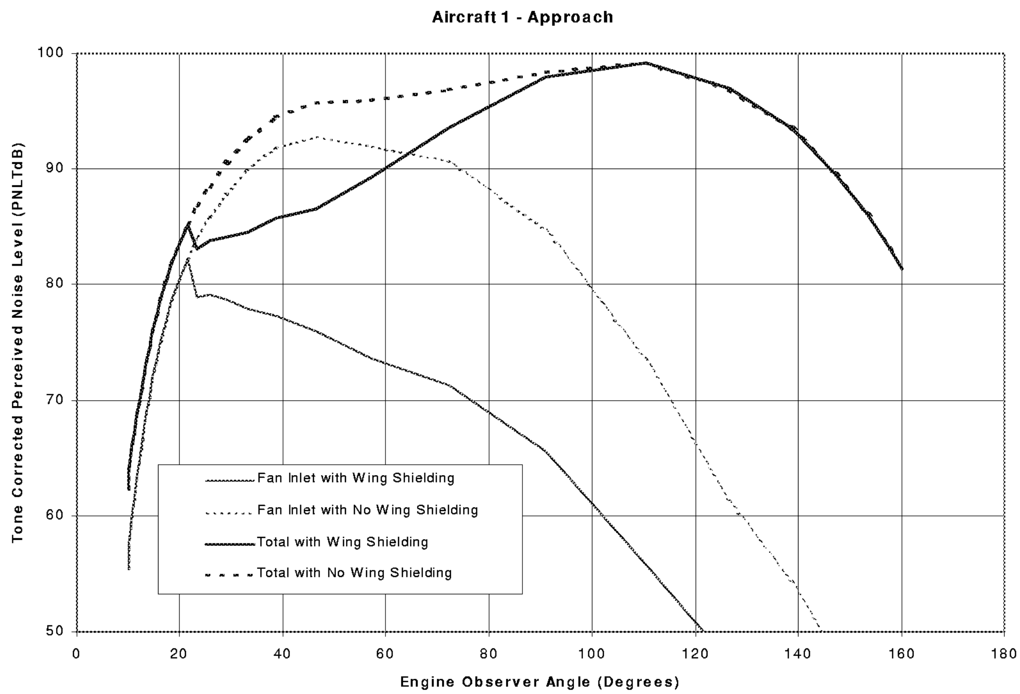


Figure 18. GASP Prediction of PNLT for Aircraft 1 at Approach Conditions, with and without Wing Shielding.

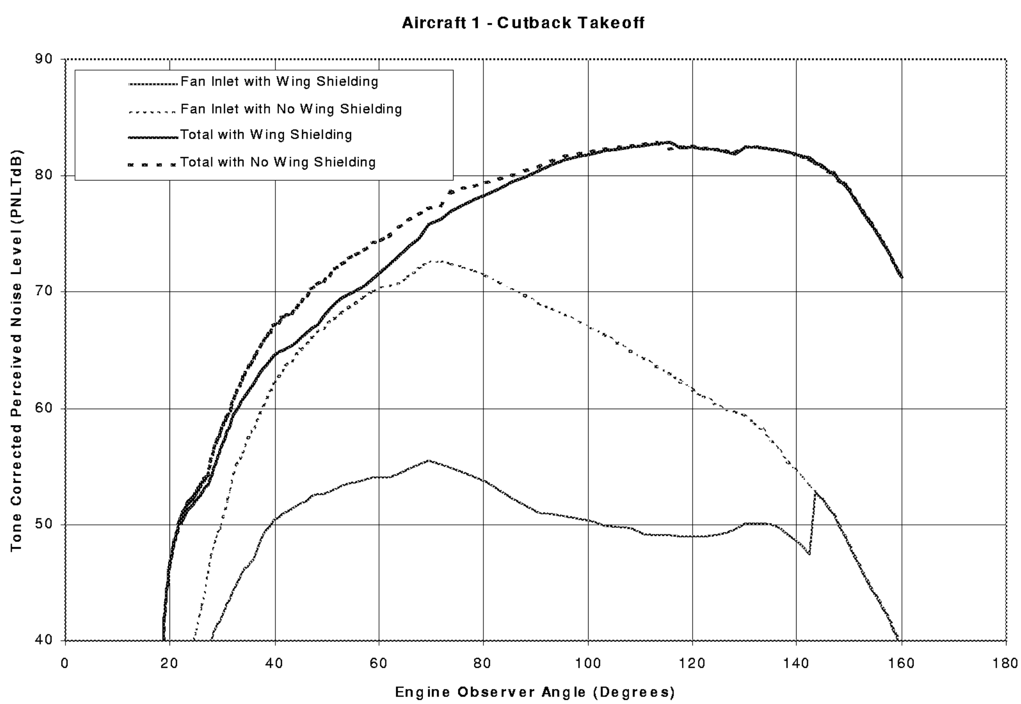


Figure 19. GASP Prediction of PNLT for Aircraft 1 at Takeoff Conditions, with and without Wing Shielding.

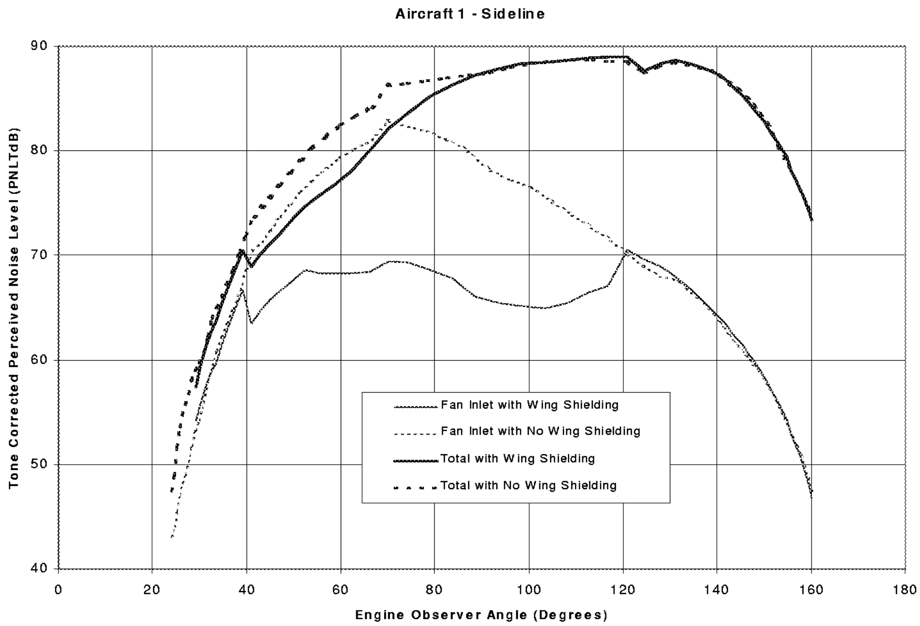


Figure 20. GASP Prediction of PNLT for Aircraft 1 at Sideline Conditions, with and without Wing Shielding.

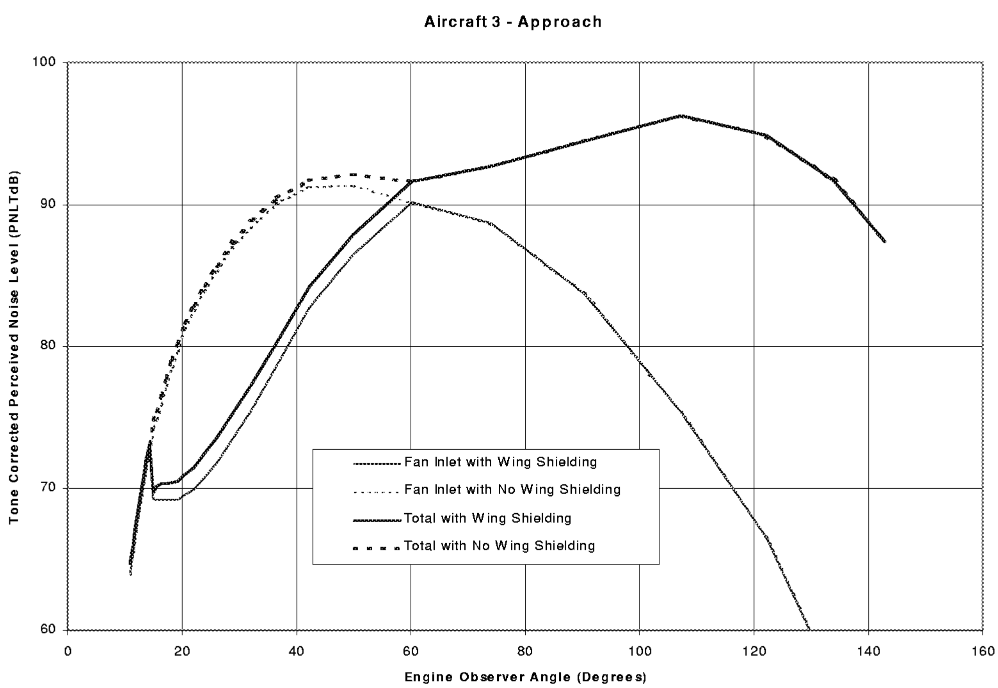


Figure 21. GASP Prediction of PNLT for Aircraft 3 at Approach Conditions, with and without Wing Shielding.

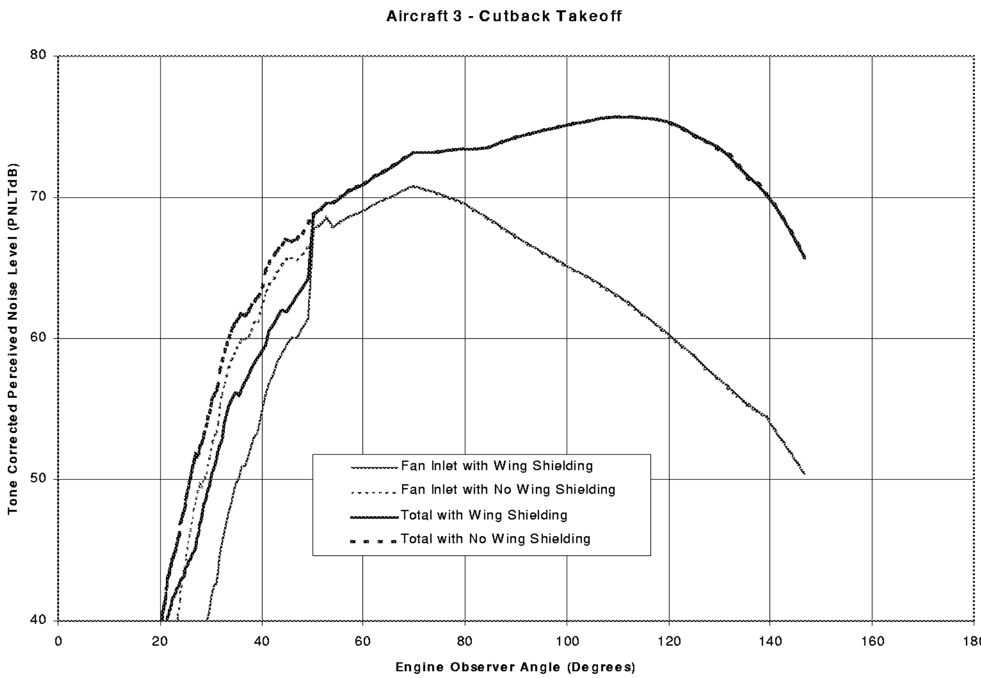


Figure 22. GASP Prediction of PNLT for Aircraft 3 at Takeoff Conditions, with and without Wing Shielding.

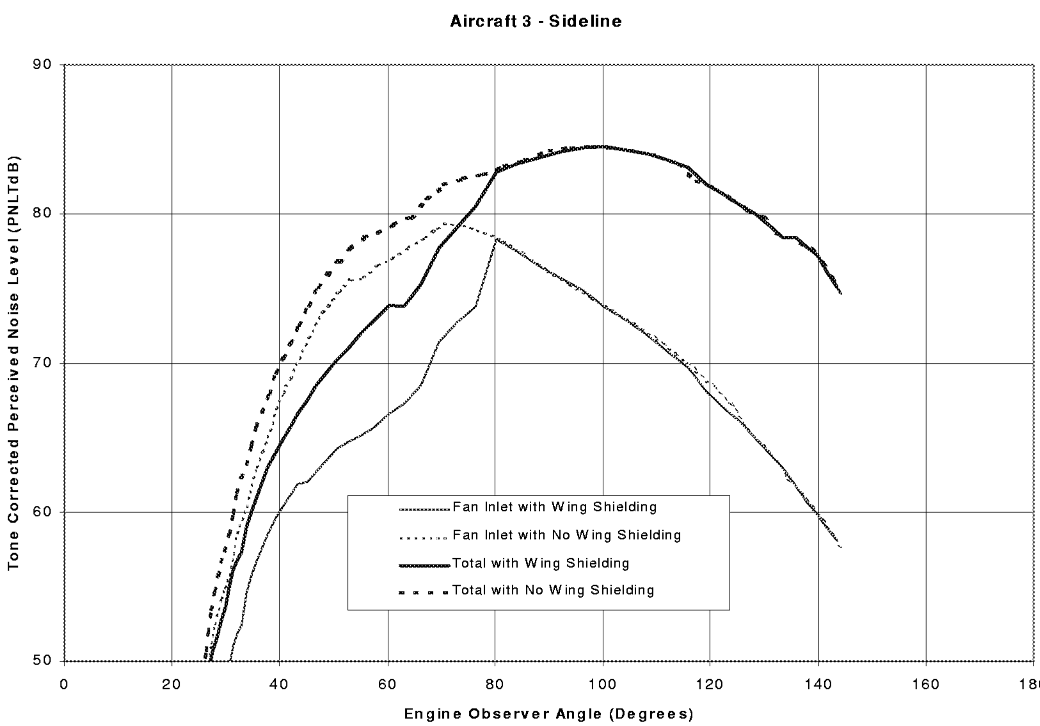


Figure 23. GASP Prediction of PNLT for Aircraft 3 at Sideline Conditions, with and without Wing Shielding.

Following installation of the wing shielding module in ANOPP, an approach analysis was performed, using the 1992 Baseline Technology business jet, to obtain predicted attenuation due to wing shielding effects. A plot of attenuation versus frequency is shown in Figure 24, for an observer angle of 48 degrees, which represents the angle of maximum attenuation at approach for this aircraft configuration.

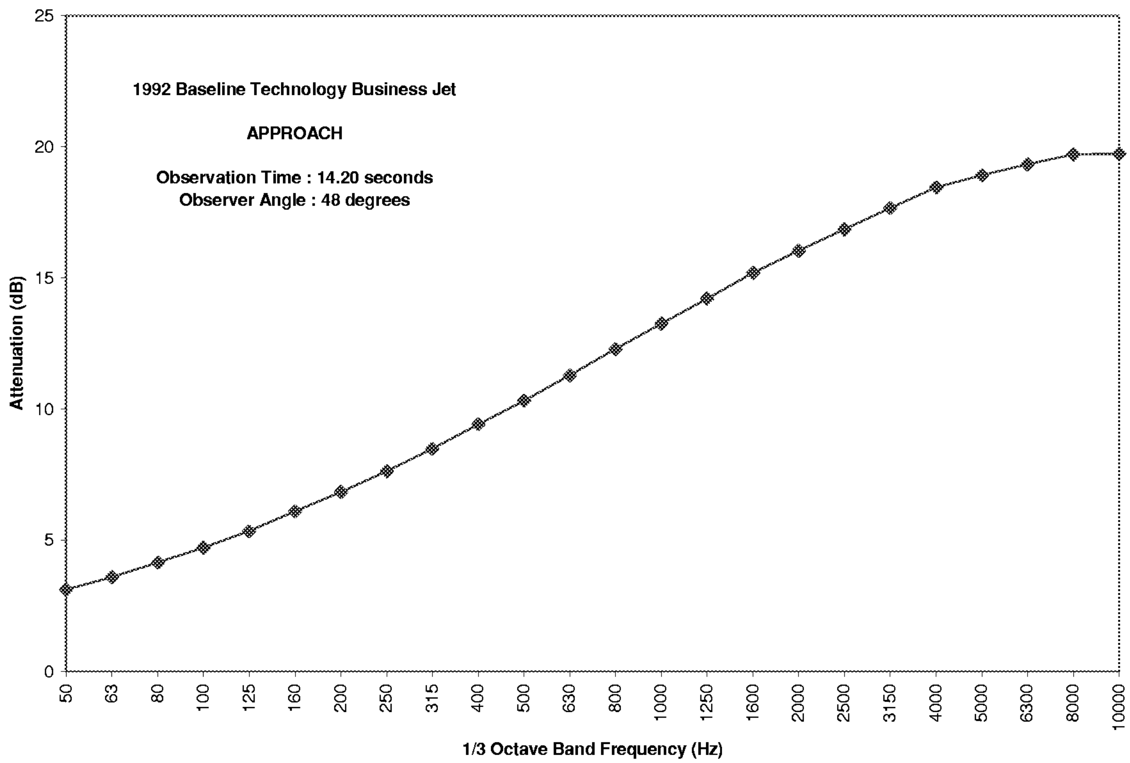


Figure 24. ANOPP Prediction of Attenuation Due to Wing Shielding for the 1992 Baseline Technology Business Jet, at Approach Conditions.

3.6 Conclusions

Introduction of the wing-shielding model in the ANOPP program allows attenuation of fan inlet noise, due to wing position, to be included in the flyover noise calculation. Inclusion of both leading and trailing edges of the wing as diffraction edges assures that the attentuation will be modeled realistically for aft-mounted engines, whether they are positioned with inlets forward or aft of the wing trailing edge.

4. SUBTASK 6: SYSTEM STUDIES OF THE BENEFITS OF THE NEW NOISE TECHNOLOGY ON BUSINESS AND REGIONAL AIRCRAFT

4.1 Technical Approach

The focus of the System Studies subtask centered on two areas:

- Updating the 1992 Baseline Technology Study,
- Applying the new technology of a porous mixer nozzle to the jet noise prediction model in ANOPP.

The AST Noise Reduction Program Office identified the following requirements for updating the 1992 Baseline Technology Study:

1) Update the GASP program to be consistent with the ANOPP small engine source noise prediction.
2) Revisit the 1992 Technology Baseline study, using the above improvements to the GASP small engine source noise prediction method.
3) Maintain constant core and turbine noise in assessing "engine noise reduction."
4) Produce the "components" of airframe noise for the baseline business jet.
5) Verify that ANOPP projections of GASP source noise produce the same EPNL results.

The following sections describe the efforts to address each of the requirements to update the Baseline Technology Study, as well as the application of the porous mixer nozzle to the ANOPP jet noise prediction.

4.2 Update of GASP Small Engine Source Noise Prediction

The 1992 Baseline Technology Study(19) was performed using Engines and Systems' noise prediction program, GASP, which closely matched the ANOPP program predictions. However, subsequent to the completion of the Baseline Technology Study, ANOPP was modified to better predict noise generation by small turbofan engines. Therefore, it became necessary to update GASP, to be consistent with the ANOPP model.

Modifications were made to the GASP fan, turbine, jet, and combustor noise modules to more closely match the ANOPP predictions. However, when the 1992 baseline engine noise levels were then recalculated and compared to the original values, the resulting overall engine noise levels were different. Because those numbers are required to remain fixed at the original levels,

small modifications needed to be made to the engines database to produce the same overall levels, with the modified GASP source predictions.

4.3 Revision of 1992 Technology Baseline Study

The 1992 baseline noise levels that were recalculated in GASP using the improved small engine noise prediction system are shown in Table 4, compared with the original baseline levels. Note that the corrections altered the calculated baseline levels. These levels were then adjusted with small cycle changes to reproduce the original levels, which were obtained as a fleet-weighted average of 1992 current-production business jets.

Table 4. Modified Calculation of 1992 Technology Baseline Levels

Original 1992 Technology Baseline Numbers (EPNdB)						
Condition	**Inlt**	**Afan**	**Turb**	**Core**	**Jet**	**Teng**
Approach	76.5	86.2	77.6	77.3	81.2	89.8
Cutback	53.4	69.8	57.2	70.1	78.6	80.4
Sideline	66.5	77.6	61.3	76.1	86.6	89.2
Predictions After GASP Modification (EPNdB)						
Condition	**Inlt**	**Afan**	**Turb**	**Core**	**Jet**	**Teng**
Approach	74.9	86.1	76.9	70.3	79.1	89.0
Cutback	50.4	67.8	55.9	62.9	76.4	78.0
Sideline	61.0	75.3	60.1	69.0	84.6	87.1
Revised Predictions to Match Original Total Engine (EPNdB)						
Condition	**Inlt**	**Afan**	**Turb**	**Core**	**Jet**	**Teng**
Approach	75.8	86.7	77.2	71.2	81.0	89.8
Cutback	55.3	71.5	60.2	64.8	78.5	80.4
Sideline	61.1	75.3	60.1	69.0	87.4	89.2

4.4 Engine Noise Reduction With Constant Core and Turbine Noise

Table 5 shows the revised calculation of the AST Noise Reduction program goals, using the updated source noise models and keeping the turbine and combustor noise fixed. Note that there is a slight decrease in the noise reduction obtained with the modeling changes.

As an additional investigation, estimates were made of the effect of further reductions of fan and jet noise on the overall engine noise levels of the 1992 baseline business jet. Of particular interest was to identify the point when jet and fan noise levels approach turbine and combustor noise levels. At this point, to further reduce engine noise levels, technology programs would have to be launched to address turbine and combustion noise reduction. The same prediction method was used for this analysis as the AST goal evaluation. Figures 25 through 27 present the results of the study. The bar charts clearly show that after about 9 dB of fan and jet noise reduction, other engine noise sources become significant.

Table 5. Modified Calculation of AST Noise Reduction Program Goals.

1992 TECHNOLOGY BASELINE LEVELS, EPNdB								
Condition	**Inlt**	**Afan**	**Turb**	**Core**	**Jet**	**Teng**	**Airf**	**TApl**
Approach	75.8	86.7	77.2	71.2	81.0	89.8	86.5	91.7
Cutback	55.3	71.5	60.2	64.8	78.5	80.4	64.3	80.6
Sideline	61.1	75.3	60.1	69.0	87.4	89.2	62.2	89.3
INTERIM PROGRAM GOALS, EPNdB								
Condition	**Inlt**	**Afan**	**Turb**	**Core**	**Jet**	**Teng**	**Airf**	**TApl**
Approach	72.8	80.2	77.2	71.2	77.9	85.3	86.5	89.3
Cutback	51.6	65.8	60.2	64.8	75.3	77.0	64.3	77.3
Sideline	57.8	69.0	60.1	69.0	84.2	85.3	62.2	85.3
FINAL PROGRAM GOALS, EPNdB								
Condition	**Inlt**	**Afan**	**Turb**	**Core**	**Jet**	**Teng**	**Airf**	**TApl**
Approach	69.7	76.3	77.2	71.2	74.8	83.2	82.4	86.2
Cutback	47.9	62.1	60.2	64.8	72.1	74.4	64.3	74.9
Sideline	54.0	65.0	60.1	68.9	81.1	82.1	62.2	82.2
MINIMUM SUCCESS PROGRAM GOALS, EPNdB								
Condition	**Inlt**	**Afan**	**Turb**	**Core**	**Jet**	**Teng**	**Airf**	**TApl**
Approach	71.8	79.2	77.2	71.2	76.9	84.7	84.4	87.9
Cutback	50.4	64.8	60.2	64.8	74.3	76.1	64.3	76.5
Sideline	56.8	68.0	60.1	68.9	83.2	84.3	62.2	84.3

OVERALL NOISE REDUCTION, EPNdB				
Condition	**Baseline**	**Interim Goal**	**Program Goal**	**Minimum Success**
Approach	0	2.4	5.5	3.8
Cutback	0	3.3	5.7	4.1
Sideline	0	3.0	7.1	5.0

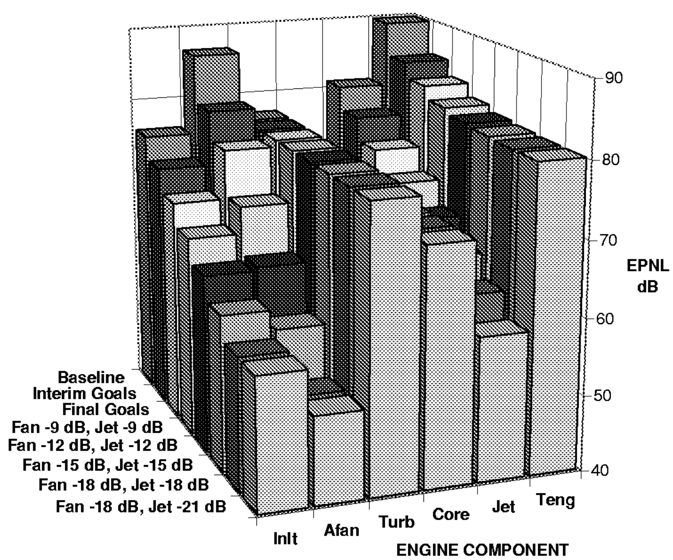


Figure 25. Impact of Further Jet and Fan Noise Reduction on the Approach Fly-Over Condition.

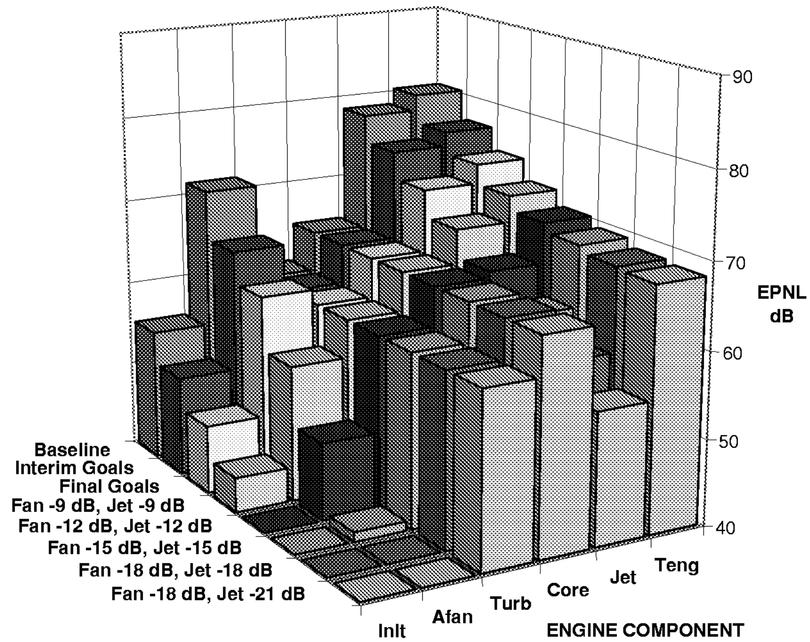


Figure 26. Impact of Further Jet and Fan Noise Reduction on the Cutback Fly-Over Condition.

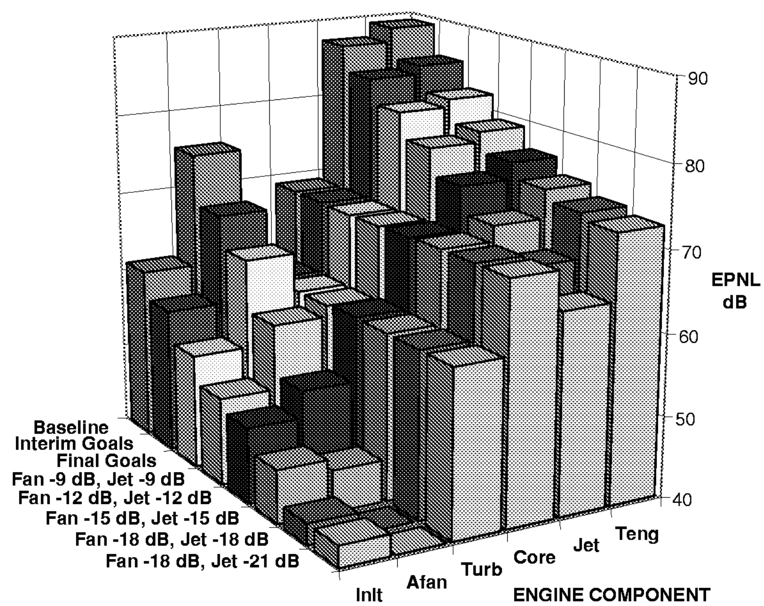


Figure 27. Impact of Further Jet and Fan Noise Reduction on the Sideline Fly-Over Condition.

4.5 Components of Airframe Noise for Baseline Business Jet

The components of airframe noise for the 1992 baseline business jet have been determined. Figures 28 through 30 show the results of the calculation. As expected, the flap edge and landing gear mechanisms dominate the airframe noise on approach. The 1992 baseline business jet does not have leading edge slats.

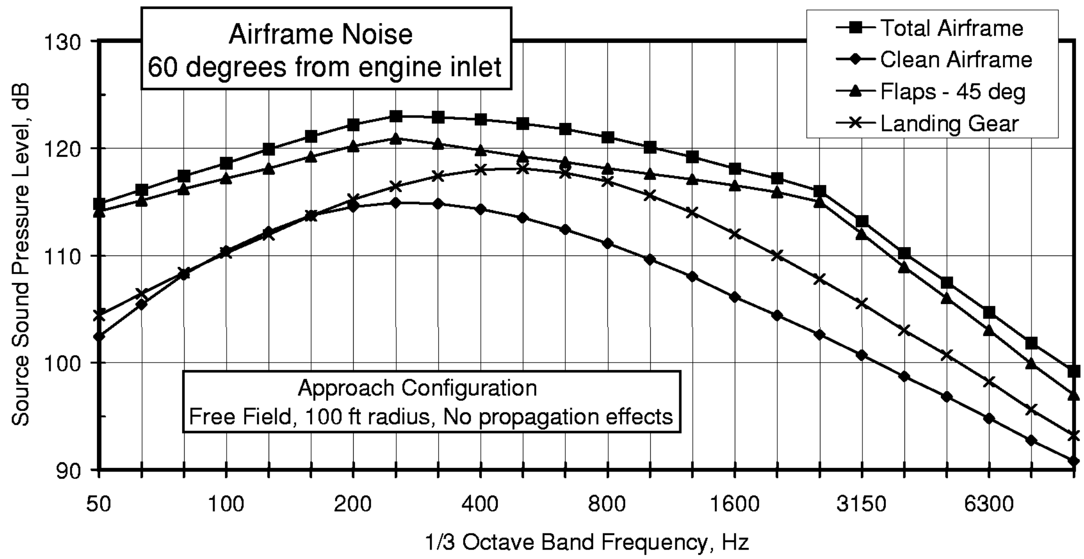


Figure 28. Airframe Noise Components for the 1992 Baseline Technology Business Jet at 60 degrees from the Inlet.

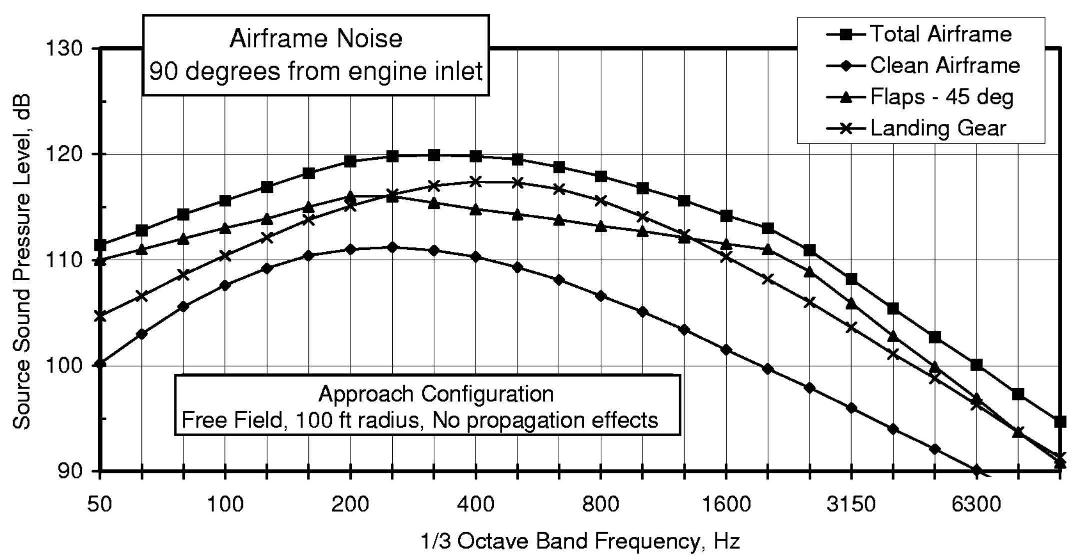


Figure 29. Airframe Noise Components for the 1992 Baseline Technology Business Jet at 90 degrees from the Inlet.

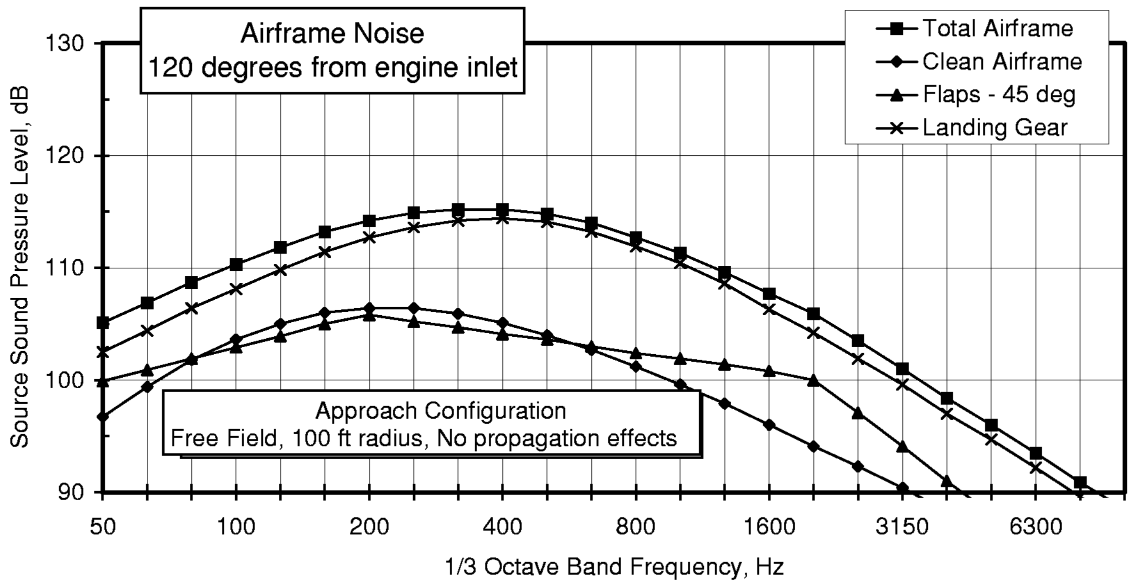


Figure 30. Airframe Noise Components for the 1992 Baseline Technology Business Jet at 120 Degrees from the Inlet.

4.6 Verification of Equivalence of ANOPP and GASP Source Noise Projections

To verify that ANOPP and GASP produced the same EPNL values from the received spectra, tables of received spectra and PNLTs were produced and transmitted to NASA Langley. The contents of these files are presented in Appendix VII.

4.7 Impact of Porous Mixer Nozzle on Jet Noise Prediction

In order to model the effects of new noise reduction technology concepts on the overall noise generated by business and regional aircraft, the database of component noise in ANOPP can be modified to reflect differences in measured noise levels resulting from testing of new technology components. In particular, the component and total noise levels measured for the porous mixer nozzle, as part of NASA SET Task 19[20], were compared with noise levels for the baseline nozzle. Differences in noise levels between the two tests were computed, representing the impact of using the porous nozzle to reduce jet noise.

A file containing the computed differences in flyover jet noise and total noise levels between the baseline nozzle and the porous mixer nozzle was prepared and transmitted to NASA Langley for installation in the ANOPP program. This data, presented in Appendix VIII for approach, cutback takeoff, and sideline, is tabulated in terms of delta values representing porous nozzle noise (dB) minus baseline reference nozzle noise (dB). The angles represent the aircraft position at each ½ second of the flyover.

5. CONCLUSIONS AND RECOMMENDATIONS

AlliedSignal Engines and Systems has completed seven separate tasks under the National Aeronautics and Space Administration (NASA)-sponsored Small Engine Technology (SET) Program, Contract No. NAS3-27483, Task Order 13, ANOPP Noise Predictions For Small Engines. These tasks focused on improving the engine noise prediction capabilities of the NASA ANOPP program for small turbofan engines.

Subtasks 1-3 are discussed in Reference (5).

Under **Subtask 4**, a semi-empirical jet noise prediction method was successfully implemented in ANOPP. The method employed a cubic-spline least-squares procedure to represent the data from a jet noise measurement database as a set of interpolation coefficients for normalized directivity, normalized power spectrum, and normalized relative spectrum functions at specific engine operating points, for a number of small turbofan engines.

Regression analyses were then performed for the combined set of engines to obtain curve fits for the interpolation coefficient data as functions of engine operating conditions. The coefficients resulting from the curve fit operation were then implemented in empirical prediction equations in ANOPP, to provide an improved procedure for the prediction of jet noise. The method was compared with two other jet noise prediction models in ANOPP, and was found to yield better agreement with data for small turbofan engines.

Under **Subtask 5**, a wing-shielding model was successfully developed and installed in the ANOPP program, to represent the attenuation caused by the aircraft wing acting as a finite barrier to engine inlet noise. The model was based on Fresnel diffraction theory for a semi-infinite barrier, with modifications to treat the finite barrier presented by the aircraft wing.

Initially, the method was implemented in the GASP program, and was demonstrated with three aircraft configurations. As expected, use of the wing shielding module attenuated the fan inlet noise, and as a result, the overall aircraft noise, relative to the unshielded case. The model was then installed in the ANOPP program, and the 1992 Baseline Technology business jet was analyzed to obtain predicted attenuation due to the wing shielding effects.

Under **Subtask 6**, the 1992 Baseline Technology Study was updated to account for improvements in the GASP program, and system studies were performed to determine overall engine noise reduction due to reductions in fan and jet noise, with combustor and turbine noise levels held constant. In addition, the jet noise reduction due to the use of a porous mixer nozzle (developed and tested as part of SET Task 19) was computed and prepared for addition to the ANOPP database.

6. REFERENCES

1) Zorumski, W.E., “Aircraft Noise Prediction Program Theoretical Manual, Parts 1 and 2,” NASA Technical Memorandums TM-83199-PT-1 and PT-2, National Aeronautics and Space Administration, Langley Research Center, Hampton, VA, February, 1982.

2) Zorumski, W.E., and Weir, D.S., “Aircraft Noise Prediction Program Theoretical Manual, Part 3,” NASA Technical Memorandum TM-83199-PT-3, National Aeronautics and Space Administration, Langley Research Center, Hampton, VA, June, 1986.

3) Hough, J.W., and Weir, D.S., “Aircraft Noise Prediction Program (ANOPP) Fan Noise Prediction for Small Engines,” NASA Report CR-198300, National Aeronautics and Space Administration; Lockheed Aeronautical Systems Co., Marietta, GA, April, 1996.

4) Hough, J., Royalty, C., and Weir, D., “ANOPP Combustion, Turbine, and Jet Noise Prediction Comparisons For Small Engines and A New Inlet Acoustic Treatment Design Module (TREAT),” NASA Report CR-201587, National Aeronautics and Space Administration, April, 1997.

5) Hough, J., and Weir, D., “Small Engine Technology (SET) - Task 13, ANOPP Noise Prediction For Small Engines: Jet, Core, and Turbine Module Revisions,” AlliedSignal Engines Report No. 21-9655, April, 1997.

6) Zorumski, W.E., and Weir, D.S., “Empirical Source Noise Prediction Method With Application to Subsonic Coaxial Jet Mixing Noise,” NASA Technical Paper TP-2084, National Aeronautics and Space Administration, Langley Research Center, Hampton, VA, December 1982.

7) Mitchell, J.A., Barton, C.K., Kisner, L.S., Lyon, C.A., “Computer Program to Predict Noise of General Aviation Aircraft: Final Report and User’s Guide,” NASA Report CR-168050, National Aeronautics and Space Administration, Lewis Research Center, September 1982.

8) Press, W.H., Teukolsky, S.A., Vetterling, W.T., and Flannery, B.P., Numerical Recipes in Fortran: The Art of Scientific Computing, 2d ed., Cambridge University Press, Cambridge, 1992, p. 108.

9) Strang, G., Linear Algebra and Its Applications, 3d ed., Harcourt Brace Jovanovich College Publishers, 1986, p. 156.

10) Kleinbaum, D.G., Kupper, L. L., Applied Regression Analysis and Other Multivariable Methods, Wadsworth Publishing Company, Inc., 1978, p. 499.

11) "Gas Turbine Jet Exhaust Noise Prediction," ARP 876, Society of Automotive Engineers, March 1978.

12) Stone, J.R., "Interim Prediction Method for Jet Noise," NASA TMX-71618, National Aeronautics and Space Administration, 1974.

13) Stone, J.R., and Montegani, F.J., "An Improved Prediction Method for the Noise Generated in Flight by Circular Jets," NASA TM-81470, National Aeronautics and Space Administration, 1980.

14) Hellstrom, G., "Noise Shielding Aircraft Configurations, A Comparison Between Predicted and Experimental Results," ICAS Paper No. 74-58, 9th Congress of the International Council of the Aeronautical Sciences, Haifa, Israel, 25-30 August 1974.

15) Bloomer, H.E., "Investigation of Wing Shielding Effects on CTOL Engine Noise," AIAA Paper 79-0669, 5th Aeroacoustic Conference, Seattle, Washington, 12-14 March 1979.

16) Raynoise is a product of LMS Numerical Technologies, a subsidiary of LMS International, Interleuvenlaan 70, 3001 Leuven - Belgium.

17) Beranek, L.L., Noise and Vibration Control, McGraw-Hill Book Company, 1971, pp. 174-180.

18) Maekawa, Z., "Noise Reduction By Screens," Applied Acoustics, Elsevier Publishing Co., Ltd., 1968, pp. 157-173.

19) Mitchell, J.A., "Final Report – Definition of 1992 Technology Noise Levels for Business Jet Aircraft and the Methodology for Assessing Airplane Noise Impact of Component Noise Reduction Concepts," AlliedSignal Engines Report 21-8867, 31 May 1995.

20) Kimbrough, A., Bouldin, B.D., Hoover, R.L., "Small Engine Technology (SET) – Task 19, Full-Scale Mixer Demonstration Final Report," AlliedSignal Engines Report 21-9606, NASA CR-1999-209169, December 1997.

APPENDIX I

ANOPP
GENERAL NOISE PREDICTION (GNP) MODULE
THEORETICAL MANUAL

(9 Pages)

GENERAL NOISE PREDICTION MODULE

INTRODUCTION

The General Noise Prediction Module produces a standard format noise table from a set of Taylor series expansions of noise data as functions of one to five independent variables. The module has standard applicability to any static noise prediction mechanism where the prediction data can be expressed in Taylor series form.

The Taylor series expansions can be provided by the Coefficient Generator and Regression spreadsheets for Excel in Office 97 that are delivered as a part of this module or directly by the user. The Taylor series expansions compute the acoustic power, 6 nodal values of the power spectrum, 7 nodal values of the overall directivity, and forty-two nodal values of the relative spectrum. These nodal values are used with a cubic spline interpolation technique to reproduce the original directivity and spectrum functions. Then, a table of mean-square acoustic pressure as a function of frequency, polar directivity angle, and azimuthal directivity angle is produced for a given value of the input parameters. Although the noise source is assumed not to vary with azimuthal directivity angle, it is introduced so that the output table is compatible with other noise tables.

SYMBOLS

A	power reference area, m^2 (ft^2)
A_e	engine reference area, m^2 (ft^2)
c_∞	ambient speed of sound, m/s (ft/s)
D	overall directivity
f	frequency, Hz
F	power spectrum
L	Strouhal number length scale, m (ft)
N	number of engines
N_P	number of independent parameters
P_{ref}	reference pressure, 2×10^{-5} N/m^2 (4.177×10^{-7} lb/ft^2)

GENERAL NOISE PREDICTION MODULE

$\langle p^2 \rangle^*$	mean-square acoustic pressure, re $\rho_\infty^2 c_\infty^4$
q	parameter index
r_s	distance from source to observer, m (ft)
R	relative spectrum
S	Strouhal number
V	Strouhal number velocity scale, m/s (ft/s)
x	independent parameters
<u>GREEK</u>	
ρ_∞	ambient density, kg/m^3 (slug/ft^3)
θ	polar directivity angle
ϕ	azimuthal directivity angle
Π^*	acoustic power, re $\rho_\infty c_\infty^3 A$
Π_{ref}	reference power, 1 x 10^{-12} watts (7.376 x 10^{-13} ft-lb/s)
<u>SUPERSCRIPT</u>	
*	dimensionless quantity

INPUT

The required values of the noise prediction parameters can be provided by the appropriate source-noise parameters module or directly by the user. The derivative tables for the Taylor series must be provided for the acoustic power, power spectrum, overall directivity, and relative spectrum. The frequency, polar directivity, and azimuthal directivity arrays establish the independent variable values for the output table. Ambient conditions are required for computation of the Strouhal number and sound pressure levels. Finally, the power-reference area, engine-reference area, number of engines, distance from source to observer, and velocity and length scales for Strouhal number computation are required.

A^*	power reference area, re A_e
A_e	engine reference area, m^2 (ft^2)

L^*	Strouhal number length scale, re $\sqrt{A_e}$
N	number of engines
r_s	distance from source to observer, m (ft)
V^*	Strouhal number velocity scale, re c_∞

Prediction Parameters

q	parameter index
x(q)	independent parameter value

Acoustic Power Derivative Table

m	derivative index
i(m),j(m),k(m)	integer function values for derivatives
$\Pi_{i,j,k}$	acoustic power derivatives

Power Spectrum Derivative Table

m	derivative index
S	Strouhal number
i(m),j(m),k(m)	integer function values for derivatives
$F_{i,j,k}(S)$	power spectrum derivatives

Overall Directivity Derivative Table

m	derivative index
θ	polar directivity angle
i(m),j(m),k(m)	integer function values for derivatives
$D_{i,j,k}(\theta)$	overall directivity derivatives

GENERAL NOISE PREDICTION MODULE

Relative Spectrum Derivative Table

m	derivative index
S	Strouhal number
θ	polar directivity angle
i(m),j(m),k(m)	integer function values for derivatives
$R_{i,j,k}(S,\theta)$	relative spectrum derivatives

Ambient Conditions

c_∞	ambient speed of sound, m/s (ft/s)
ρ_∞	ambient density, kg/m^3 (slug/ft^3)

Independent Variable Arrays

f	frequency, Hz
θ	polar directivity angle
ϕ	azimuthal directivity angle

OUTPUT

The output of this module is a table of the mean-square acoustic pressure as a function of frequency, polar directivity angle, and azimuthal directivity angle. In addition, the observer distance, r_s, is required for the Propagation module.

r_s	distance from source to observer, m (ft)

Noise Table

f	frequency, Hz
θ	polar directivity angle
ϕ	azimuthal directivity angle

GENERAL NOISE PREDICTION MODULE

$<p^2>^*(f,\theta,\phi)$ mean-square acoustic pressure, re $\rho_\infty^2 c_\infty^4$

METHOD

Mean-Square Acoustic Pressure Relation

The acoustic power of the source is obtained by integrating the mean-square acoustic pressure over the surface of a sphere of radius r_s by the relation

$$\Pi = \frac{4\pi r_s^2}{\rho_\infty c_\infty} \frac{1}{2} \int_{-\infty}^{\infty} \int_0^{\pi} < p^2 > (S,\theta) \sin\theta d\theta dS \tag{1}$$

assuming symmetry in the azimuthal spherical coordinate. Expressing Equation 1 in dimensionless form and the mean-square pressure in standard one-third octave bands yields

$$\Pi^* = \frac{4\pi (r_s^*)^2}{A^*} \frac{1}{2} \int_0^{\pi} \sum_{i=1}^{\infty} < p^2 >^* (S_i,\theta) \sin\theta d\theta \tag{2}$$

The definition of the normalized power spectrum is

$$F(S_i) = \frac{4\pi (r_s^*)^2}{\Pi^* A^*} \frac{1}{2} \int_0^{\pi} < p^2 >^* (S_i,\theta) \sin\theta d\theta \tag{3}$$

and the definition of the normalized directivity is

$$D(\theta) = \frac{4\pi (r_s^*)^2}{\Pi^* A^*} \sum_{i=1}^{\infty} < p^2 >^* (S_i,\theta) \tag{4}$$

Substitution of Equation 3 into 2 yields the normalization condition for the power spectrum as

$$\sum_{i=1}^{\infty} F(S_i) = 1 \tag{5}$$

Similarly, substitution of Equation 4 into 2 yields the normalization condition of the overall directivity as

$$\frac{1}{2}\int_0^{\pi} D(\theta)\sin\theta d\theta = 1 \tag{6}$$

Defining a relative spectrum as

$$R(S_i,\theta) = \frac{4\pi(r_s^*)^2}{\Pi^* A^*}\frac{<p^2>^*(S_i,\theta)}{F(S_i)D(\theta)} \tag{7}$$

yields an explicit expression for the mean-square acoustic pressure in terms of the acoustic power as

$$< p^2 >^* (S_i,\theta) = \frac{\Pi^* A^*}{4\pi(r_s^*)^2} F(S_i)D(\theta)R(S_i,\theta) \tag{8}$$

Substituting Equation 8 into Equations 2, 3, and 4 yields the three relative spectrum normalization conditions as

$$\frac{1}{2}\int_0^{\pi}\left[\sum_{i=1}^{\infty} F(S_i)D(\theta)R(S_i,\theta)\right]\sin\theta d\theta = 1 \tag{9}$$

$$\frac{1}{2}\int_0^{\pi} D(\theta)R(S_i,\theta)\sin\theta d\theta = 1 \tag{10}$$

and

$$\sum_{i=1}^{\infty} F(S_i) R(S_i, \theta) = 1 \tag{11}$$

Equation 8 provides a very convenient way to analyze empirical values of the mean-square acoustic pressure. By determining the relationships for the acoustic power, power spectra, overall directivity, and relative spectra separately, the data is more easily managed and the effects of independent variables and parameters isolated. In addition, if the interaction between the Strouhal number, S_i, and the polar directivity angle, θ, can be neglected, Equation 8 is greatly simplified by the elimination of the two-dimensional relative spectrum function.

Taylor Series Evaluation

The implementation of the noise prediction methodology is based on the evaluation of Taylor series expansions derived from empirical data. These series provide the acoustic power, Π^*, seven nodal values of the overall directivity, $D(\theta)$, six nodal values of the power spectrum, $F(S_i)$, and 42 nodal values of the relative spectrum, $R(S_{i,} \theta)$. These nodal values, along with cubic spline interpolation with the appropriate boundary conditions, produce the desired noise values for given values of the prediction parameters, frequency, and polar directivity angle.

For the purposes of this module, the Taylor series has been simplified to a polynomial of order 3 in each of the independent variables, including the cross terms. For the acoustic power, this equation can be expressed as:

$$\Pi^* = \sum_{m=1}^{56} \Pi_{ijk} x_i x_j x_k \tag{12}$$

where the integer functions i(m), j(m), and k(m) can take on values from 1 to 5 signifying the index q of the prediction parameter x(q). The value of x_0 is defined to be 1. Therefore, Π_{000} is the constant term, Π_{220} is the coefficient of the x_2^2 term, and Π_{345} is the coefficient of the $x^3 x^4 x^5$ term. The nodal values for the power spectrum, F, overall directivity, D, and relative

spectrum, R, are computed in the same manner. These polynomials are formed by a least-squares fit of the nodal values to the prediction parameter values.

Cubic Spline Data Interpolation

The derivatives of the acoustic power, power spectrum, overall directivity, and relative spectrum are determined by smoothing the empirical data and deriving Taylor series expansions of the resulting nodal values of the cubic spline interpolation. This process typically results in the following nodal values:

- Acoustic power Π^* (one value)
- Power spectrum $F(S_j)$ at $\log_{10}(S_j)$ values of –1.5, -1.0, -0.5, 0., 0.5, 1.0 (6 values)
- Overall directivity $D(\theta_i)$ at θ_i values of 0, 30, 60, 90, 120, 150, 180 degrees (7 values)
- Relative spectrum $R(S_j, \theta_i)$ at the same values of $\log_{10}(S_j)$ and θ_i values (42 values)

It is desired to compute the mean-square acoustic pressure at the values of the frequency, polar directivity, and azimuthal directivity requested in the input Independent Variable Arrays. A standard cubic spline routine from the LAPACK library (http://www.netlib.org/lapack/) is used to evaluate the spectrum and directivity functions. This routine preserves the zero slope boundary condition for the directivity shape and the zero curvature boundary condition for the spectrum shape.

Noise Prediction

The method for the preparation of the output noise table is as follows:

1. From the values of the input parameters, $x(q)$, evaluate the acoustic power, the seven values of the overall directivity, the six values of the power spectrum, and the 42 values of the relative spectrum from the corresponding Taylor series.
2. Interpolate for the desired values of the overall directivity, power spectrum, and relative spectrum, given the independent variable values of polar directivity angle, θ, and Strouhal number, $\log_{10}S_i$. The Strouhal number is computed as

$$S_i = \frac{f^* L^*}{V^*} \tag{13}$$

where $f^* = f\sqrt{A_e}\,/\,c_\infty$.

3. Compute the mean-square acoustic pressure at the desired values of frequency and polar directivity angle using Equation 8.

The output table values are the mean-square acoustic pressure values multiplied by the number of engines, N, as a function of frequency, polar directivity angle, and azimuthal directivity angle. In addition, printed output is available of the mean-square pressure, $<p^2>^*$, sound pressure level, SPL, defined as

$$SPL = 10\log_{10} < p^2 >^* + 20\log_{10} \frac{\rho_\infty c_\infty^2}{p_{ref}} \tag{14}$$

and the power level, PWL, defined as

$$PWL = 10\log_{10} \Pi^* + 20\log_{10} \frac{\rho_\infty c_\infty^3 A^* A_e}{\Pi_{ref}} \tag{15}$$

APPENDIX II

ANOPP
GENERAL NOISE PREDICTION (GNP) MODULE
USER'S MANUAL

(3 Pages)

GENERAL NOISE PREDICTION MODULE

```
SUBROUTINE GNP
***
*       PURPOSE - TO PRODUCE A NOISE TABLE FROM A TAYLOR SERIES
*                 REPRESENTATION OF NOISE DATA AS A FUNCTION OF ONE TO
*                 FIVE INDEPENDENT PARAMETERS.  THIS MODULE HAS
*                 GENERAL APPLICABILITY TO ANY STATIC NOISE PREDICTION
*                 MECHANISM WHERE THE PREDICTION DATA BASE CAN BE
*                 EXPRESSED IN TAYLOR SERIES FORM.
*
*       AUTHOR  - DSW(L03/02/11)
*
*       INPUT                                                  DEFAULT
*         USER PARAMETERS                                     SI UNITS
*           AE         ENGINE REFERENCE AREA (RS), M**2        1.
*                      (FT**2)
*           AP         POWER REFERENCE AREA  (RS), RE AE       1.
*           CA         AMBIENT SPEED OF SOUND (RS), M/SEC      340.294
*                      (FT/SEC)
*           LS         STROUHAL NUMBER LENGTH SCALE (RS),      1.
*                      RE SQRT(AE)
*           RHOA       AMBIENT DENSITY (RS), KG/M**3           1.225
*                      (SLUG/FT**3)
*           RS         DISTANCE FROM SOURCE TO OBSERVER (RS),  1.
*                      M  (FT)
*           VS         STROUHAL NUMBER VELOCITY SCALE, RE CA   1.
*           IOUT       TABLE OUTPUT AND PRINT OUTPUT OPTION (I) 3
*                       0, NO PRINT, BUT GENERATE TABLE
*                          GNP(XXXNNN)
*                      -1, PRINT OUTPUT IN DB UNITS, BUT DO
*                          NOT GENERATE TABLE GNP(XXXNNN)
*                      -2, PRINT OUTPUT IN DIMENSIONLESS FORM,
*                          BUT DO NOT GENERATE TABLE GNP(XXXNNN)
*                      -3, BOTH OPTIONS -1 AND -2
*                       1, PRINT OUTPUT IN DB UNITS AND
*                          GENERATE TABLE GNP(XXXNNN)
*                       2, PRINT OUTPUT IN DIMENSIONLESS FORM
*                          AND GENERATE TABLE GNP(XXXNNN)
*                       3, BOTH OPTIONS 1 AND 2
*           IPRINT     PRINT OPTION CODE (I)                   3
*                       0  NO PRINT DESIRED
*                       1  INPUT PRINT ONLY
*                       2  OUTPUT PRINT ONLY
*                       3  BOTH INPUT AND OUTPUT PRINT
*           NENG       NUMBER OF ENGINES (I)                   1
*           SCRNNN     INTEGER VALUE, NNN, .GT. 0, USED TO     1
*                      FORM TABLE UNIT MEMBER NAME GNP(XXXNNN)
*           SCRXXX     THREE LETTER CODE, XXX, USED TO FORM    3HXXX
*                      TABLE UNIT MEMBER NAME GNP(XXXNNN)
*           STIME      SOURCE TIME (RS), SEC                   0.0
*           IUNITS     INPUT UNITS FLAG                        2HSI
*                      7HENGLISH, ENGLISH UNITS
*                      2HSI,      SI UNITS
*           XPARAM     MULTI-ELEMENT PARAMETER OF 5 WORDS OR   1.,1.,
*                      LESS CONTAINING VALUES FOR THE          1.,1.,
*                      INDEPENDENT PARAMETERS                  1.
*
```

```
*          DATA BASE UNIT MEMBERS
*            (DESCRIBED UNDER DATA BASE STRUCTURES)
*            SFIELD(FREQ)    -  FREQUENCY VALUES
*            SFIELD(THETA)   -  POLAR DIRECTIVITY ANGLE VALUES
*            SFIELD(PHI)     -  AZIMUTHAL DIRECTIVITY ANGLE VALUES
*            TSE   (OAPWL)   -  ACOUSTIC POWER DATA
*            TSE   (PSLFIT)  -  POWER SPECTRUM DATA
*            TSE   (DIRFIT)  -  OVERALL DIRECTIVITY DATA
*            TSE   (RSLFIT)  -  RELATIVE SPECTRAL DATA
*
*        OUTPUT
*          USER PARAMETER
*            RS         DISTANCE FROM SOURCE TO OBSERVER (RS),
*                       M  (FT)
*
*          SYSTEM PARAMETER
*            NERR       .TRUE.  - IMPLIES AN ERROR WAS ENCOUNTERED
*                                 DURING MODULE EXECUTION
*                       .FALSE. - NO ERROR ENCOUNTERED
*
*          DATA BASE UNIT MEMBERS
*            GNP(XXXNNN)   SEE FORMAT UNDER DATA BASE STRUCTURES.
*                          NOTE MEMBER NAME XXXNNN IS FORMED FROM
*                          USER PARAMETERS SCRXXX AND SCRNNN.
*                          OUTPUT OF THIS TABLE IS CONTROLLED BY
*                          USER PARAMETER IOUT.
*
*        DATA BASE STRUCTURES
*          SFIELD( FREQ )  1 RECORD MEMBER IN *RS FORMAT CONTAINING
*                          VALUES OF 1/3 OCTAVE BAND CENTER FREQUENCIES
*                          IN HZ.
*          SFIELD(THETA)   1 RECORD MEMBER IN *RS FORMAT CONTAINING
*                          VALUES OF POLAR DIRECTIVITY ANGLE
*                          IN DEGREES
*          SFIELD( PHI )   1 RECORD MEMBER IN *RS FORMAT CONTAINING
*                          VALUES OF AZIMUTHAL DIRECTIVITY ANGLE
*                          IN DEGREES
*          GNP   (XXXNNN)  TYPE 1 DATA TABLE CONTAINING MEAN SQUARE
*                          PRESSURE AS A FUNCTION OF (1) FREQUENCY,
*                          (2) DIRECTIVITY ANGLE AND (3) AZIMUTHAL
*                          ANGLE
*          TSE(OAPWL)
*            RECORD  WORD                DESCRIPTION
*              1             FORMAT 3I
*                     1      NUMBER OF INDEPENDENT PARAMETERS, NPARM
*                     2      NUMBER OF DERIVATIVES IN THE DERIVATIVE
*                            MATRIX, NDERV (NUMBER OF ROWS)
*                     3      NUMBER OF INDEPENDENT VARIABLE VALUES, NIV
*                            ASSOCIATED WITH THE DEPENDENT VARIABLE
*                            (I.E., NUMBER OF "NDERV" DERIVATIVES IN
*                            THE DERIVATIVE MATRIX - NUMBER OF COLUMNS)
*              2             FORMAT *RS
*                    1,3     INTEGER FUNCTION VALUES OF DERIVATIVE
*                            INCLUDED IN THE FIRST ROW OF THE
```

```
*                              DERIVATIVE MATRIX
*                   4,6        FUNCTION VALUES FOR SECOND ROW
*                    .
*                    .
*                 3*NDERV
*             3                FORMAT *RS
*                    -         DERIVATIVE MATRIX, SIZE(NDERV,NIV)
*          TSE(PSLFIT)      SAME FORMAT AS TSE(OAPWL)
*          TSE(DIRFIT)      SAME FORMAT AS TSE(OAPWL)
*          TSE(RSLFIT)      SAME FORMAT AS TSE(OAPWL)
*
*        ERRORS
*          NON-FATAL
*            1.  INSUFFICIENT LOCAL DYNAMIC STORAGE.
*            2.  MEMBER MANAGER ERROR OCCURRED ON SPECIFIED UNIT MEMBER.
*            3.  USER PARAMETER VALUE OUT OF RANGE. DEFAULT VALUE WILL
*                BE USED.
*            4.  SPECIFIED UNIT MEMBER IS NOT AVAILABLE.
*          FATAL - NONE
*
*        LDS REQUIREMENTS
*         LENGTH = NFREQ + NTHETA + NPHI + ( ( NTHETA * NPHI ) *
*                  ( NFREQ + 1 ) ) + ( ND1 * 4 ) + ( ND2 * 8 ) +
*                  ( ND3 * 8 ) + ( ND4 * 28 )
*           WHERE
*             NFREQ  = NUMBER OF FREQUENCY VALUES
*             NTHETA = NUMBER OF POLAR DIRECTIVITY ANGLES
*             NPHI   = NUMBER OF AZIMUTHAL DIRECTIVITY ANGLES
*             ND1    = NUMBER OF DERIVATIVES IN DERIVATIVE MATRIX OF THE
*                      ACOUSTIC POWER DATA
*             ND2    = NUMBER OF DERIVATIVES IN DERIVATIVE MATRIX OF THE
*                      POWER SPECTRUM DATA
*             ND3    = NUMBER OF DERIVATIVES IN DERIVATIVE MATRIX OF THE
*                      OVERALL DIRECTIVITY DATA
*             ND4    = NUMBER OF DERIVATIVES IN DERIVATIVE MATRIX OF THE
*                      RELATIVE SPECTRAL DATA
*
*        GDS REQUIREMENTS
*          SUFFICIENT ALLOCATION FOR THE FOLLOWING TABLE(S) :
*            GNP(XXXNNN)
***
```

APPENDIX III

ANOPP
GENERAL NOISE PREDICTION (GNP) MODULE
TEST CASE INPUT AND OUTPUT

(17 Pages)

GENERAL NOISE PREDICTION MODULE TEST CASE: INPUT FILE

```
ANOPP JECHO=.FALSE. JLOG=.FALSE.  $
  STARTCS $
  SETSYS JCON=.TRUE. $
  $
  $ GNP TEST CASE
  $
  $
  $  NAMELIST "ENV" IS ENTERED
  $
  $
  PARAM IUNITS   = 7HENGLISH $  ENGLISH UNITS
  PARAM TAMB     = 520.7     $  AMBIENT TEMPERATURE, DEG R
  PARAM PAMB     = 2008.7    $  AMBIENT PRESSURE, PSF
  PARAM RH       = 15.9      $  RELATIVE HUMIDITY, PERCENT
  PARAM DIST     = 1.        $  DISTANCE FOR STATIC PREDICTIONS, FT
  PARAM MIXPR    = 1.4674    $  MIXED STREAM PRESSURE RATIO
  PARAM MIXTR    = 1.4971    $  MIXED STREAM TEMPERATURE RATIO
  PARAM AREAR    = 0.3974    $  AREA RATIO
  $
  $
  $  THE ANGLE ARRAY IS NOW ENTERED
  $
  $
  UPDATE NEWU=SFIELD SOURCE=* $
  -ADDR OLDM=* NEWM=FREQ  FORMAT=4H*RS$ $  1/3 OCTAVE CENTER FREQUENCIES
                   20.   25.   31.5  40.   50.   63.   80.   100.
      125.   160.   200.  250.  315.  400.  500.  630.  800.  1000.
     1250.  1600.  2000. 2500. 3150. 4000. 5000. 6300. 8000. 10000.
    12500. 16000. 20000. $
  -ADDR OLDM=* NEWM=THETA FORMAT=4H*RS$ $  POLAR DIRECTIVITY ANGLES
      10. 20. 30. 40. 50. 60. 70. 80. 90. 100. 110. 120. 130. 140.
     150. 160. $
  -ADDR OLDM=* NEWM=PHI   FORMAT=4H*RS$ $ AZIMUTH DIRECTIVITY ANGLES
       0. $  SOURCES ARE AXISYMMETRIC
  END* $
  $
  $  NOW THE ENGINE THERMODYNAMIC DATA ARE ENTERED.
  $
  $
  PARAM VJ       = 956.5     $  FULLY EXPANDED JET VELOCITY, FPS
  PARAM TJ       = 766.8     $  JET TOTAL TEMPERATURE, DEG R
  PARAM DJ       = 1.939     $  JET OUTER DIAMETER, FT
  PARAM GAMJ     = 1.333     $  JET RATIO OF SPECIFIC HEATS
  $
  $
  $  PARAMETERS FOR THE GNP MODULE ARE NOW DEFINED:
  $
  $
  PARAM    AE = 1. $
  EVALUATE CA = 1116.45 * SQRT ( TAMB / 518.67) $
  EVALUATE LS = DJ / SQRT ( AE ) $
  EVALUATE RHOA = 0.002378 * ( 518.57 / TAMB ) * (PAMB / 2116.22 ) $
  PARAM    RS = 100. $
  EVALUATE VS = VJ / CA $
  PARAM    XPARAM = 1., 1., 1. $
  EVALUATE XPARAM(1) = AREAR $
  EVALUATE XPARAM(2) = MIXPR $
```

GENERAL NOISE PREDICTION MODULE TEST CASE: INPUT FILE

```
EVALUATE XPARAM(3) = MIXTR $
$
$
$  ENTER TAYLOR SERIES EXPANSIONS
$
$
UPDATE NEWU=TSE SOURCE=* $
-ADDR OLDM=* NEWM= OAPWL FORMAT=0 $
     3 10 1 $
     0. 0. 0.
     1. 0. 0.
     1. 1. 0.
     1. 1. 1.
     2. 0. 0.
     2. 2. 0.
     2. 2. 2.
     3. 0. 0.
     3. 3. 0.
     3. 3. 3. $
     -318.1, -5867.7, 14889.9,-12548.6,  -537.4,
      508.9,  -151.6,  2861.9, -2004.2,   479.4  $
-ADDR OLDM=* NEWM=DIRFIT FORMAT=0 $
     3 10 7  $
     0. 0. 0.
     1. 0. 0.
     1. 1. 0.
     1. 1. 1.
     2. 0. 0.
     2. 2. 0.
     2. 2. 2.
     3. 0. 0.
     3. 3. 0.
     3. 3. 3. $
     -253.2, 13823.6,-34953.9, 28962.2,   661.6,
     -499.4,   129.2,  -3755.0,  2567.2,  -593.1,
      917.0,   465.4,  -1183.2,  1038.6,   554.7,
     -451.0,   122.5,  -2562.9,  1811.2,  -431.1,
      594.7,   -69.1,    206.3,  -136.6,   448.9,
     -367.8,   101.1,  -1657.3,  1187.6,  -288.9,
      666.2,  -154.8,    346.2,  -185.6,   482.0,
     -388.2,   105.1,  -1813.2,  1301.2,  -315.6,
      230.8,   826.8,  -2136.9,  1846.5,   440.4,
     -330.7,    84.3,  -1106.3,   774.2,  -183.6,
     -260.4,  -401.8,   1036.7,  -911.0,    28.6,
       -5.1,    -4.0,    621.9,  -440.2,   106.5,
   -1346.4,  7211.7, -17857.4, 14296.8,  1326.2,
     -986.4,   236.2,   -392.4,   263.8,   -49.8  $
-ADDR OLDM=* NEWM=PSLFIT FORMAT=0 $
     3 10 6 $
     0. 0. 0.
     1. 0. 0.
     1. 1. 0.
     1. 1. 1.
     2. 0. 0.
     2. 2. 0.
     2. 2. 2.
     3. 0. 0.
```

```
      3. 3. 0.
      3. 3. 3. $
       360.8,  591.2, -1621.1,   1461.3,   460.0,
      -344.9,   89.6, -1439.0,   1062.5,  -264.0,
      -286.8, 1427.9, -3654.4,   3068.4,    23.5,
         3.4,   -6.5,   200.2,   -175.6,    49.7,
       249.8,-1759.1,  4488.1,  -3761.5,    78.8,
       -93.2,   30.9,  -130.2,    110.3,   -30.6,
       709.4,-1021.5,  2574.4,  -2087.0,   418.2,
      -343.6,   94.8, -1645.7,   1188.0,  -289.3,
       529.3, -861.6,  2121.2,  -1675.3,   466.6,
      -382.4,  103.9, -1360.3,    990.9,  -243.6,
       373.3, 3750.5, -9739.9,   8405.1,   381.1,
      -301.8,   84.5, -2190.8,   1552.2,  -376.3  $
-ADDR OLDM=* NEWM=RSLFIT FORMAT=0 $
      3 10 42 $
      0. 0. 0.
      1. 0. 0.
      1. 1. 0.
      1. 1. 1.
      2. 0. 0.
      2. 2. 0.
      2. 2. 2.
      3. 0. 0.
      3. 3. 0.
      3. 3. 3. $
      -2775.3,   2150.8, -5290.5,  4284.8, -1528.5,
       1107.0,   -269.5,  6531.7, -4466.6,  1019.7,
        708.6,   -603.9,  1566.5, -1343.2,  -129.6,
         62.9,     -7.7, -1185.4,   837.6,  -196.1,
       -499.2,   1092.0, -2786.7,  2346.5,  -138.1,
        142.5,    -43.8,   828.3,  -576.2,   133.2,
       -739.8,    951.5, -2394.0,  1937.7,  -288.2,
        256.3,    -75.2,  1582.6, -1153.6,   282.8,
       -935.2,   1375.7, -3523.8,  2930.1,  -567.8,
        468.9,   -127.5,  2126.7, -1523.6,   365.4,
      -1153.1,   2807.7, -7231.6,  6085.4,  -596.5,
        503.9,   -139.2,  2254.9, -1638.9,   397.3,
        450.2,   1784.9, -4451.9,  3651.6,  -979.2,
        711.3,   -174.9,  -365.8,   152.3,    -9.0,
         87.1,   -304.3,   802.5,  -685.3,  -230.7,
        150.5,    -31.7,    96.4,   -42.4,     3.7,
       -247.0,   1040.1, -2626.7,  2179.8,   -16.9,
         45.8,    -18.8,   219.5,  -161.5,    39.9,
       -530.5,    984.8, -2495.5,  2027.6,  -385.9,
        316.9,    -87.4,  1231.8,  -902.0,   223.3,
       -546.0,   1214.0, -3110.7,  2577.1,  -433.6,
        358.2,    -97.9,  1248.5,  -916.5,   226.5,
       -893.5,   2535.1, -6552.8,  5519.7,  -664.0,
        539.6,   -144.9,  1856.3, -1354.5,   330.7,
       -954.0,   4873.2,-12415.6, 10420.7, -1431.2,
       1064.3,   -263.6,  2013.2, -1410.7,   330.2,
        -46.0,    188.9,  -546.7,   516.2,   -11.2,
        -17.7,     11.4,    34.1,    16.4,   -14.0,
        -63.6,    706.1, -1758.9,  1440.5,   -27.8,
         58.5,    -23.1,   -46.6,     6.5,     4.9,
       -538.4,    396.4,  -957.1,   711.8,  -506.5,
```

```
       412.7,    -112.8,  1509.6, -1097.8,    269.5,
      -463.6,     368.0,  -913.9,   704.4,   -617.7,
       499.2,    -134.2,  1465.9, -1068.8,    262.5,
      -769.7,    1076.0, -2760.2,  2280.9,   -772.8,
       622.6,    -166.9,  2069.4, -1497.1,    363.6,
     -1618.4,    3750.5, -9593.4,  8077.7,    -73.2,
        76.5,     -25.6,  2443.1, -1726.5,    407.0,
       241.7,      71.4,  -208.8,   205.9,     78.9,
       -75.5,      23.8,  -614.0,   454.1,   -112.9,
      -150.9,     604.4, -1500.8,  1218.4,    -81.5,
        90.9,     -29.8,   214.3,  -170.1,     45.4,
      -726.2,     793.1, -1958.6,  1544.9,   -559.5,
       437.9,    -115.5,  1838.5, -1311.4,    315.3,
      -657.5,     405.1,  -983.1,   736.5,   -611.5,
       474.2,    -123.5,  1843.8, -1309.4,    313.6,
      -840.2,     893.2, -2252.1,  1815.4,   -673.0,
       520.9,    -135.5,  2152.2, -1521.4,    362.1,
      -263.5,    5493.3,-14076.6, 11894.9,   -445.9,
       374.1,    -100.9,  -400.7,   170.0,    -17.6,
       206.8,    -268.9,   675.3,  -548.3,    -77.2,
        43.9,      -6.8,  -301.0,   229.6,    -58.7,
       -21.7,      79.1,  -181.9,   124.6,     18.5,
        11.7,      -9.6,    -4.2,   -14.8,      9.1,
      -438.9,    -180.7,   471.1,  -440.9,   -265.1,
       211.7,     -57.7,  1214.9,  -860.8,    206.5,
      -289.2,    -592.1,  1530.1, -1342.8,   -218.0,
       176.0,     -48.9,   960.6,  -679.2,    163.8,
      -591.2,    -722.4,  1857.0, -1615.4,   -302.5,
       238.4,     -64.7,  1714.8, -1208.7,    287.8,
       301.7,   -3913.2,  9948.4, -8315.3,    -11.8,
       -30.6,      16.6,   391.1,  -204.4,     32.2,
       -36.8,     586.2, -1485.6,  1246.5,     69.2,
       -46.9,      10.4,  -125.6,    71.9,    -13.6,
      -372.2,    -786.2,  1988.8, -1682.2,   -739.8,
       510.9,    -117.8,  1693.8, -1152.6,    261.7,
       410.1,   -2075.8,  5266.1, -4396.3,   -333.7,
       211.8,     -42.2,   -14.5,    57.3,    -25.9,
       294.5,   -1964.3,  4951.3, -4098.2,   -122.3,
        62.4,      -7.4,     6.3,    29.7,    -16.7,
       967.4,   -3396.8,  8687.2, -7310.4,     72.7,
      -110.5,      41.5, -1229.8,   926.2,   -231.5,
       -162.0,-20694.1, 53740.4,-46110.5,   -139.8,
       -162.5,     75.5,  5707.8, -3631.1,    803.3,
     -1097.6,    4504.5,-11546.7,  9808.0,   -669.8,
       531.0,    -134.5,  1667.2, -1149.6,    256.7,
      -787.1,    3979.7,-11135.6, 10196.7,  -3946.1,
      2968.2,    -726.2,  4377.3, -3062.9,    694.0,
       -73.6,   -5346.7, 12857.9,-10196.2,  -2666.7,
      1975.9,    -481.2,  4177.2, -2902.4,    664.6,
        17.3,   -6246.0, 14961.1,-11705.7,  -2702.2,
      2058.0,    -512.5,  4277.6, -3023.7,    700.2,
       836.5,  -11313.9, 28155.5,-23060.9,  -2399.5,
      1745.3,    -420.2,  3591.8, -2467.6,    562.5  $
END* $
  PROCEED $
$
$  JET PARAMETERS
```

GENERAL NOISE PREDICTION MODULE TEST CASE: INPUT FILE

```
$
$
PARAM    PIE    = 3.14159 $
EVALUATE AJ     = PIE * DJ ** 2 / 4.
                          $  COMPUTE JET AREA
EVALUATE TJ     = TJ / TAMB
                          $  NORMALIZE JET TOTAL TEMPERATURE
EVALUATE VJ     = VJ / CA $  NORMALIZE JET VELOCITY
EVALUATE RHOJ   = 1. / ( TJ - ( GAMJ - 1 ) / 2. * VJ**2 )
                          $  COMPUTE NORMALIZED JET DENSITY
PARAM    CIRCLE = .TRUE.  $  REQUEST SINGLE JET FORM STONE'S METHOD
PARAM      IOUT = 1       $  PRINT DB ONLY
$
$
$  LOAD UNITS FROM DATA LIBRARY
$
$
LOAD /LIBRARY/ SAE PROCLIB STNTBL $
$
$
$  PREDICT SOURCE NOISE
$
$
EXECUTE SGLJET $
EXECUTE STNJET A1=AJ DE1=DJ DH1=DJ V1=VJ T1=TJ RHO1=RHOJ $
PARAM METHOD = 2 $
EXECUTE SGLJET $
EXECUTE STNJET A1=AJ DE1=DJ DH1=DJ V1=VJ T1=TJ RHO1=RHOJ $
EXECUTE GNP AP=AJ $
ENDCS $
```

```
             NNNN      NNNN        NNNN        NNNNNNNNNNNN        NNNN
           NNNNNNNN    NNNN      NNNNNNNN     NNNNNNNNNNNNN      NNNNNNNN
           NNNN NNNN   NNNN     NNNN  NNNN   NNNN               NNNN  NNNN
           NNNN NNNN   NNNN     NNNN  NNNN   NNNN               NNNN  NNNN
           NNNN  NNNN  NNNN    NNNN    NNNN   NNNNNNNNNNN      NNNN    NNNN
           NNNN  NNNN  NNNN    NNNN    NNNN    NNNNNNNNNNN     NNNN    NNNN
           NNNN   NNNN NNNN   NNNN      NNNN           NNNN   NNNN      NNNN
           NNNN   NNNN NNNN   NNNN      NNNN           NNNN   NNNN      NNNN
           NNNN    NNNNNNNN  NNNN        NNNNNNNNNNNNNNNNN   NNNN        NNNN
           NNNN      NNNN    NNNN        NNNNNNNNNNNNNNNN    NNNN        NNNN


  NNNNNNNNNNNN    NNNN        NNNN    NNNNNNNNNNNN    NNNNNNNNNNNNNN    NNNNNNNNNNNNNN
 NNNNNNNNNNNNNN   NNNN        NNNN   NNNNNNNNNNNNNN   NNNNNNNNNNNNNNN   NNNNNNNNNNNNNNN
NNNNNNNNNNNNNNNN  NNNNN       NNNN  NNNNNNNNNNNNNNNN  NNNNNNNNNNNNNNNN  NNNNNNNNNNNNNNNN
NNNNN      NNNNN  NNNNNN      NNNN  NNNNN      NNNNN  NNNN       NNNNN  NNNN       NNNNN
NNNN        NNNN  NNNNNNN     NNNN  NNNN        NNNN  NNNN        NNNN  NNNN        NNNN
NNNN        NNNN  NNNNNNNN    NNNN  NNNN        NNNN  NNNN        NNNN  NNNN        NNNN
NNNN        NNNN  NNNN NNNN   NNNN  NNNN        NNNN  NNNN        NNNN  NNNN        NNNN
NNNN        NNNN  NNNN  NNNN  NNNN  NNNN        NNNN  NNNN       NNNNN  NNNN       NNNNN
NNNNNNNNNNNNNNNN  NNNN   NNNN NNNN  NNNN        NNNN  NNNNNNNNNNNNNNNN  NNNNNNNNNNNNNNNN
NNNNNNNNNNNNNNNN  NNNN    NNNNNNNN  NNNN        NNNN  NNNNNNNNNNNNNNN   NNNNNNNNNNNNNNN
NNNNNNNNNNNNNNNN  NNNN     NNNNNNN  NNNN        NNNN  NNNNNNNNNNNNNN    NNNNNNNNNNNNNN
NNNN        NNNN  NNNN      NNNNNN  NNNNN      NNNNN  NNNN              NNNN
NNNN        NNNN  NNNN       NNNNN  NNNNNNNNNNNNNNNN  NNNN              NNNN
NNNN        NNNN  NNNN        NNNN   NNNNNNNNNNNNNN   NNNN              NNNN
NNNN        NNNN  NNNN        NNNN    NNNNNNNNNNNN    NNNN              NNNN
```

```
1                                  6/21/99            ANOPP LEVEL 03/02/11                        PAGE      1

                                                   ANOPP INITIALIZATION PHASE

                         ANOPP JECHO=.FALSE. JLOG=.FALSE.  $
                           STARTCS $

                                                    ANOPP EXECUTIVE PARAMETERS
                                                    --------------------------

          NOGO = F                 JECHO = F                                 JLOG = F

                                     MAXIMUM TABLE DIRECTORY ENTRIES                =      10

                                     MAXIMUM UNIT DIRECTORY ENTRIES                 =      25

                                     CHECKPOINT FILE (IF REQUESTED)                 = CPFILE

                                     NUMBER OF LINES PER PAGE                       =      48

                                     MAXIMUM NUMBER OF CARDS IN PRIMARY INPUT STREAM =   10000

                                     MAXIMUM LENGTH OF GLOBAL DYNAMIC STORAGE       =   12000


****************** DBM INFORMATIVE MESSAGE   76 *** XUPNEW - UNIT SFIELD   IS BEING CREATED
DYNAMICALLY.******************
 APPLICABLE DIAGNOSTIC MESSAGES PRECEDE CARD IMAGE

                                                       HEADER SECTION

 UPDATE PROCESSING BEGINNING WITH THE FOLLOWING PARAMETERS
 CREATE   MODE                   NEW DATA UNIT = SFIELD                      OLD DATA UNIT = NONE
 SOURCE OF UPDATE DIRECTIVES IS PRIMARY INPUT STREAM                         LIST = NONE

****************** DBM INFORMATIVE MESSAGE   76 *** XUPNEW - UNIT TSE      IS BEING CREATED
DYNAMICALLY.******************
 APPLICABLE DIAGNOSTIC MESSAGES PRECEDE CARD IMAGE

                                                       HEADER SECTION

 UPDATE PROCESSING BEGINNING WITH THE FOLLOWING PARAMETERS
 CREATE   MODE                   NEW DATA UNIT = TSE                         OLD DATA UNIT = NONE
 SOURCE OF UPDATE DIRECTIVES IS PRIMARY INPUT STREAM                         LIST = NONE
```

```
1                                  6/21/99             ANOPP LEVEL 03/02/11                     PAGE      2

                                           SINGLE  STREAM  CIRCULAR  JET  NOISE  MODULE

                                  MODULE SGLJET USES THE FOLLOWING INPUT PARAMETERS AND UNIT MEMBERS

     AJ     =  2.9529          RHOJ   =  .74025          TJ     =  1.4726          VJ     =  .85506          RS     =
100.00
     RHOA   =  .22479E-02      IUNITS =    ENGLISH       CA     =  1118.6          MA     =  .00000E+00      AE     =
1.0000
     DELTA  =  .00000E+00      NENG   =   1              SCRXXX = XXX              SCRNNN =  1               IOUT   =  1
     IPRINT =  3               STIME  =  .00000E+00      SHOCK  =  F               METHOD =  1



                                    SFIELD  (FREQ    ) IS ALTERNATE NAME OF SFIELD  (FREQ    )
                                    SFIELD  (PHI     ) IS ALTERNATE NAME OF SFIELD  (PHI     )
                                    SFIELD  (THETA   ) IS ALTERNATE NAME OF SFIELD  (THETA   )
                                    SAE     (MTH     ) IS ALTERNATE NAME OF SAE     (MTH     )
                                    SAE     (OM      ) IS ALTERNATE NAME OF SAE     (OM      )
                                    SAE     (PDF     ) IS ALTERNATE NAME OF SAE     (PDF     )
                                    SAE     (NDF     ) IS ALTERNATE NAME OF SAE     (NDF     )
                                    SAE     (SJC     ) IS ALTERNATE NAME OF SAE     (SJC     )
                                    SAE     (SCF     ) IS ALTERNATE NAME OF SAE     (SCF     )
                                    SGLJET  (XXX001  ) IS ALTERNATE NAME OF SGLJET  (XXX001  )
1                                  6/21/99             ANOPP LEVEL 03/02/11                     PAGE      3

                                           SINGLE  STREAM  CIRCULAR  JET  NOISE  MODULE


****************** DBM INFORMATIVE MESSAGE   76 *** MMOPWD - UNIT SGLJET   IS BEING CREATED
DYNAMICALLY.*****************
                                                        NOISE DATA FROM MODULE SGLJET

         OBSERVER DISTANCE =    100.0      (FT)    REFERENCE LENGTH =   1.718      (FT)    POWER LEVEL =   142.6    DB
                                                             SOURCE TIME =   .0000E+00

                                  SINGLE STREAM CIRCULAR JET NOISE CALCULATED BASED ON SAE ARP 876
```

SINGLE STREAM CIRCULAR JET NOISE MODULE

```
**************************************************
* TABLE OF SOUND PRESSURE LEVEL VALUES (DECIBELS) *
**************************************************
```

AZIMUTH ANGLE = .00 DEGREES

1/3 OB CTR FREQ (HERTZ)	DIRECTIVITY ANGLE (DEGREES) 10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0	160.0
OVERALL	94.4	94.7	95.0	95.4	95.7	96.3	96.5	97.3	98.2	99.4	101.1	103.0	104.9	106.5	107.5	107.5
20.00	67.6	67.9	68.2	68.6	68.9	69.5	69.7	70.5	71.4	72.1	72.9	74.1	76.3	79.7	81.4	83.7
25.00	69.6	69.9	70.2	70.6	71.0	71.5	71.8	72.5	73.5	74.3	75.2	76.9	79.2	82.9	84.8	86.7
31.50	71.7	72.0	72.3	72.7	73.0	73.6	73.9	74.6	75.5	76.6	77.6	79.2	81.6	85.3	87.7	89.5
40.00	73.8	74.1	74.4	74.8	75.2	75.7	76.0	76.7	77.7	78.8	80.0	81.6	84.1	87.8	90.6	92.4
50.00	75.9	76.2	76.5	76.9	77.2	77.8	78.0	78.8	79.7	80.7	82.2	83.7	86.2	90.2	93.2	95.1
63.00	77.4	77.7	78.0	78.4	78.7	79.3	79.5	80.3	81.2	82.4	83.9	85.6	88.0	92.1	95.2	97.0
80.00	78.9	79.2	79.5	79.9	80.2	80.8	81.1	81.8	82.7	84.1	85.7	87.4	89.8	93.8	97.1	98.7
100.00	80.2	80.5	80.8	81.2	81.6	82.1	82.4	83.1	84.1	85.4	87.1	88.8	91.3	95.1	98.4	99.5
125.00	81.3	81.6	81.9	82.3	82.7	83.2	83.5	84.2	85.2	86.5	88.3	90.0	92.4	96.1	98.9	99.5
160.00	82.3	82.6	82.9	83.3	83.6	84.2	84.5	85.2	86.1	87.4	89.4	91.1	93.5	96.7	98.5	98.5
200.00	82.9	83.2	83.5	83.9	84.2	84.8	85.1	85.8	86.7	88.2	90.0	91.7	94.1	96.7	97.5	97.0
250.00	83.3	83.6	83.9	84.3	84.6	85.2	85.4	86.2	87.1	88.7	90.4	92.1	94.4	96.7	96.5	95.2
315.00	83.4	83.7	84.0	84.4	84.8	85.3	85.6	86.3	87.3	88.8	90.4	92.2	94.4	96.1	95.0	93.1
400.00	83.4	83.7	84.0	84.4	84.7	85.3	85.5	86.3	87.2	88.6	90.3	92.1	94.1	95.2	93.3	91.2
500.00	83.3	83.6	83.9	84.3	84.6	85.2	85.5	86.2	87.1	88.4	90.1	92.0	93.7	94.4	91.7	89.4
630.00	82.8	83.1	83.4	83.8	84.1	84.7	84.9	85.7	86.6	87.8	89.5	91.4	92.8	93.0	90.1	87.4
800.00	82.2	82.5	82.8	83.2	83.5	84.1	84.4	85.1	86.0	87.2	88.9	90.8	91.9	91.6	88.4	85.4
1000.00	81.7	82.0	82.3	82.7	83.0	83.6	83.9	84.6	85.5	86.6	88.4	90.2	91.0	90.3	86.8	83.5
1250.00	81.2	81.5	81.8	82.2	82.5	83.1	83.4	84.1	85.0	86.1	87.8	89.6	90.1	89.0	85.3	81.7
1600.00	80.5	80.8	81.1	81.5	81.8	82.4	82.7	83.4	84.3	85.3	87.1	88.8	89.1	87.5	83.5	79.6
2000.00	79.6	79.9	80.2	80.6	80.9	81.5	81.8	82.5	83.4	84.4	86.1	87.8	87.9	86.0	81.9	77.7
2500.00	78.7	79.0	79.3	79.7	80.0	80.6	80.8	81.6	82.5	83.5	85.2	86.8	86.8	84.6	80.3	75.9
3150.00	77.7	78.0	78.3	78.7	79.1	79.6	79.9	80.6	81.6	82.5	84.2	85.7	85.6	83.1	78.6	73.9
4000.00	76.8	77.1	77.4	77.8	78.1	78.7	78.9	79.7	80.6	81.6	83.2	84.6	84.4	81.5	76.9	72.0
5000.00	75.8	76.1	76.4	76.8	77.2	77.7	78.0	78.7	79.7	80.6	82.2	83.6	83.2	80.1	75.2	70.1
6300.00	74.6	74.9	75.2	75.6	75.9	76.5	76.8	77.5	78.4	79.4	81.0	82.3	81.9	78.5	73.5	68.2
8000.00	73.3	73.6	73.9	74.3	74.6	75.2	75.5	76.2	77.1	78.2	79.8	81.0	80.5	77.0	71.7	66.2
10000.00	72.1	72.4	72.7	73.1	73.4	74.0	74.3	75.0	75.9	77.0	78.6	79.8	79.2	75.5	70.1	64.3
12500.00	70.9	71.2	71.5	71.9	72.2	72.8	73.0	73.8	74.7	75.8	77.5	78.5	77.9	74.1	68.4	62.4
16000.00	69.5	69.8	70.1	70.5	70.9	71.4	71.7	72.4	73.4	74.5	76.2	77.2	76.5	72.5	66.6	60.4
20000.00	68.3	68.6	68.9	69.3	69.7	70.2	70.5	71.2	72.1	73.3	75.0	76.0	75.2	71.0	64.9	58.5

```
1                                  6/21/99             ANOPP LEVEL 03/02/11                     PAGE      5

                                                     STONE JET NOISE MODULE

                                                        INPUT PARAMETERS

      AE     =    .10000000E+01       A1      =    .29528755E+01       A2      =    .00000000E+00       CA      =
.11186327E+04
      DELTA  =    .00000000E+00       DE1     =    .19390000E+01       DH1     =    .19390000E+01       MA      =
.00000000E+00
      M1     =    .10000000E+01       M2      =    .00000000E+00       RHOA    =    .22479463E-02       RHO1    =
.74024738E+00
      RHO2   =    .10000000E+01       RS      =    .10000000E+03       T1      =    .14726330E+01       T2      =
.10000000E+01
      V1     =    .85506174E+00       V2      =    .00000000E+00       IOUT    =      1                 IPRINT =       3
      METHOD =      1
      NENG   =      1                 SCRNNN =      1                  SCRXXX =    XXX                  STIME   =
.00000000E+00
      IUNITS =    ENGLISH             SUPER   =      F                 CIRCLE =      T                  PLUG    =       F



                                                         UNIT MEMBERS

                                    SFIELD  (FREQ    ) IS ALTERNATE NAME OF SFIELD  (FREQ    )
                                    STNTBL  (FSP     ) IS ALTERNATE NAME OF STNTBL  (FSP     )
                                    STNTBL  (JDF     ) IS ALTERNATE NAME OF STNTBL  (JDF     )
                                    STNJET  (XXX001  ) IS ALTERNATE NAME OF STNJET  (XXX001  )
                                    SFIELD  (PHI     ) IS ALTERNATE NAME OF SFIELD  (PHI     )
                                    STNTBL  (SDF     ) IS ALTERNATE NAME OF STNTBL  (SDF     )
                                    SFIELD  (THETA   ) IS ALTERNATE NAME OF SFIELD  (THETA   )
1                                  6/21/99             ANOPP LEVEL 03/02/11                     PAGE      6

                                                     STONE JET NOISE MODULE

****************** DBM INFORMATIVE MESSAGE   76 *** MMOPWD - UNIT STNJET   IS BEING CREATED
DYNAMICALLY.******************
                                                     NOISE DATA FROM MODULE STNJET

         OBSERVER DISTANCE =    100.0     (FT)    REFERENCE LENGTH =   1.718     (FT)    POWER LEVEL =   .0000E+00DB
                                                       SOURCE TIME =   .0000E+00

                                                     SUBSONIC CIRCULAR NOZZLE
```

GENERAL NOISE PREDICTION MODULE TEST CASE: OUTPUT FILE

STONE JET NOISE MODULE

****
* TABLE OF SOUND PRESSURE LEVEL VALUES (DECIBELS) *
****

AZIMUTH ANGLE = .00 DEGREES

1/3 OB CTR FREQ (HERTZ)	DIRECTIVITY ANGLE (DEGREES)															
	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0	160.0
OVERALL	94.0	94.2	94.6	95.1	95.7	96.4	97.3	98.3	99.5	100.7	102.0	103.4	104.8	106.1	107.3	108.2
20.00	66.4	66.6	66.8	67.1	67.5	68.1	68.7	69.5	70.3	71.3	72.4	73.5	76.7	79.8	81.4	82.9
25.00	68.7	68.8	69.0	69.4	69.8	70.4	71.0	71.8	72.6	73.6	74.7	75.8	79.3	83.0	84.8	85.7
31.50	70.9	71.0	71.3	71.6	72.0	72.6	73.2	74.0	74.9	75.9	77.0	78.1	82.1	86.4	88.2	88.6
40.00	73.2	73.3	73.6	73.9	74.3	74.9	75.5	76.3	77.2	78.2	79.2	80.4	84.8	89.8	91.1	91.1
50.00	75.3	75.5	75.7	76.1	76.5	77.1	77.7	78.5	79.4	80.4	81.4	82.6	87.4	92.5	93.3	92.6
63.00	77.2	77.3	77.6	78.0	78.5	79.1	79.8	80.6	81.5	82.5	83.6	84.8	89.7	94.4	94.9	94.1
80.00	78.7	78.8	79.1	79.5	80.0	80.7	81.4	82.3	83.2	84.3	85.4	86.8	91.5	95.5	96.8	95.5
100.00	79.7	79.9	80.2	80.6	81.2	81.8	82.6	83.5	84.5	85.6	86.8	88.4	93.0	96.4	98.0	96.5
125.00	80.7	80.8	81.1	81.6	82.1	82.8	83.6	84.5	85.5	86.6	87.8	89.9	94.5	97.3	99.0	97.2
160.00	81.5	81.7	82.0	82.5	83.0	83.7	84.5	85.4	86.5	87.6	88.8	91.4	95.2	97.8	99.4	97.4
200.00	82.1	82.3	82.6	83.1	83.7	84.4	85.2	86.1	87.2	88.4	89.6	92.4	95.5	97.5	98.7	96.5
250.00	82.5	82.7	83.1	83.5	84.1	84.8	85.7	86.7	87.7	88.9	90.2	93.0	95.4	97.0	97.5	94.7
315.00	82.8	83.0	83.3	83.8	84.4	85.1	86.0	87.0	88.1	89.3	90.6	93.1	94.8	96.0	95.8	92.8
400.00	82.9	83.1	83.4	83.9	84.6	85.3	86.2	87.2	88.3	89.5	90.8	92.9	93.8	94.5	94.0	90.9
500.00	82.8	83.0	83.3	83.8	84.5	85.2	86.1	87.1	88.3	89.5	90.9	92.5	92.7	93.1	92.3	89.1
630.00	82.6	82.8	83.1	83.7	84.3	85.1	86.0	87.0	88.2	89.4	90.8	92.0	91.6	91.5	90.6	87.2
800.00	82.1	82.3	82.7	83.2	83.8	84.7	85.6	86.7	87.8	89.1	90.5	91.3	90.3	89.9	88.8	85.2
1000.00	81.4	81.7	82.0	82.6	83.2	84.1	85.0	86.1	87.3	88.6	90.0	90.5	89.1	88.4	87.1	83.4
1250.00	80.8	81.0	81.4	81.9	82.6	83.4	84.3	85.4	86.7	88.0	89.4	89.6	87.9	87.0	85.4	81.6
1600.00	79.9	80.2	80.5	81.1	81.8	82.6	83.6	84.7	85.9	87.2	88.6	88.6	86.6	85.3	83.5	79.6
2000.00	79.0	79.3	79.6	80.2	80.9	81.7	82.7	83.8	85.1	86.4	87.8	87.5	85.4	83.8	81.8	77.8
2500.00	78.0	78.2	78.6	79.2	79.9	80.8	81.7	82.9	84.1	85.5	86.9	86.5	84.2	82.3	80.1	76.0
3150.00	76.9	77.1	77.5	78.1	78.8	79.6	80.6	81.8	83.0	84.4	85.9	85.4	82.9	80.8	78.3	74.1
4000.00	75.8	76.0	76.4	76.9	77.7	78.5	79.5	80.6	81.9	83.3	84.7	84.2	81.6	79.2	76.5	72.1
5000.00	74.7	74.9	75.3	75.9	76.6	77.4	78.4	79.6	80.8	82.2	83.7	83.0	80.3	77.7	74.8	70.3
6300.00	73.5	73.7	74.1	74.7	75.4	76.2	77.2	78.4	79.7	81.0	82.5	81.8	79.0	76.2	73.1	68.4
8000.00	72.3	72.5	72.9	73.4	74.1	75.0	76.0	77.1	78.4	79.8	81.3	80.6	77.7	74.6	71.2	66.5
10000.00	71.1	71.4	71.8	72.3	73.1	73.9	74.9	76.1	77.3	78.7	80.1	79.4	76.5	73.1	69.5	64.7
12500.00	70.0	70.2	70.6	71.2	71.9	72.8	73.8	74.9	76.2	77.6	79.0	78.3	75.2	71.6	67.8	62.9
16000.00	68.7	68.9	69.3	69.9	70.6	71.5	72.5	73.6	74.9	76.3	77.7	77.0	73.9	70.0	66.0	60.8
20000.00	67.5	67.8	68.2	68.7	69.4	70.3	71.3	72.5	73.7	75.1	76.6	75.8	72.6	68.5	64.3	59.0

```
1                            6/21/99           ANOPP LEVEL 03/02/11                  PAGE     8

                                   SINGLE  STREAM  CIRCULAR  JET  NOISE  MODULE

                             MODULE SGLJET USES THE FOLLOWING INPUT PARAMETERS AND UNIT MEMBERS

    AJ     =  2.9529         RHOJ   =  .74025        TJ     =  1.4726        VJ     =  .85506        RS     =
100.00
    RHOA   =  .22479E-02     IUNITS =   ENGLISH      CA     =  1118.6        MA     =  .00000E+00    AE     =
1.0000
    DELTA  =  .00000E+00     NENG   =   1            SCRXXX = XXX            SCRNNN =  1             IOUT   =  1
    IPRINT =  3              STIME  =  .00000E+00    SHOCK  =  F             METHOD =  2



                              SFIELD  (FREQ    ) IS ALTERNATE NAME OF SFIELD  (FREQ    )
                              SFIELD  (PHI     ) IS ALTERNATE NAME OF SFIELD  (PHI     )
                              SFIELD  (THETA   ) IS ALTERNATE NAME OF SFIELD  (THETA   )
                              SAE     (MTH     ) IS ALTERNATE NAME OF SAE     (MTH     )
                              SAE     (OM      ) IS ALTERNATE NAME OF SAE     (OM      )
                              SAE     (PDF     ) IS ALTERNATE NAME OF SAE     (PDF     )
                              SAE     (NDF     ) IS ALTERNATE NAME OF SAE     (NDF     )
                              SAE     (SJC     ) IS ALTERNATE NAME OF SAE     (SJC     )
                              SAE     (SCF     ) IS ALTERNATE NAME OF SAE     (SCF     )
                              SGLJET  (XXX001  ) IS ALTERNATE NAME OF SGLJET  (XXX001  )
1                            6/21/99           ANOPP LEVEL 03/02/11                  PAGE     9

                                   SINGLE  STREAM  CIRCULAR  JET  NOISE  MODULE

                                       NOISE DATA FROM MODULE SGLJET

      OBSERVER DISTANCE =    100.0     (FT)    REFERENCE LENGTH =   1.718     (FT)    POWER LEVEL =   141.6    DB
                                               SOURCE TIME =   .0000E+00

                             SINGLE STREAM CIRCULAR JET NOISE CALCULATED BASED ON SAE ARP 876
```

SINGLE STREAM CIRCULAR JET NOISE MODULE

```
**************************************************
* TABLE OF SOUND PRESSURE LEVEL VALUES (DECIBELS) *
**************************************************
```

AZIMUTH ANGLE = .00 DEGREES

1/3 OB CTR FREQ (HERTZ)	DIRECTIVITY ANGLE (DEGREES) 10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0	160.0
OVERALL	88.4	89.9	90.7	91.6	92.3	93.3	93.8	94.9	96.1	97.5	99.4	101.6	103.8	106.0	107.5	108.5
20.00	61.6	63.1	63.9	64.8	65.5	66.5	67.0	68.1	69.3	70.2	71.2	72.7	75.2	79.2	81.4	84.7
25.00	63.6	65.1	65.9	66.8	67.6	68.5	69.1	70.1	71.4	72.5	73.5	75.5	78.1	82.4	84.8	87.7
31.50	65.7	67.2	68.0	68.9	69.6	70.6	71.2	72.2	73.4	74.7	75.9	77.8	80.6	84.8	87.7	90.5
40.00	67.8	69.3	70.1	71.0	71.8	72.7	73.3	74.3	75.6	76.9	78.3	80.2	83.0	87.3	90.6	93.4
50.00	69.9	71.4	72.2	73.1	73.8	74.8	75.3	76.4	77.6	78.8	80.5	82.3	85.1	89.7	93.2	96.1
63.00	71.4	72.9	73.7	74.6	75.3	76.3	76.9	77.9	79.1	80.5	82.2	84.2	86.9	91.6	95.2	98.0
80.00	72.9	74.4	75.2	76.1	76.8	77.8	78.4	79.4	80.6	82.2	84.0	86.0	88.7	93.3	97.1	99.7
100.00	74.2	75.7	76.5	77.4	78.2	79.1	79.7	80.7	82.0	83.5	85.4	87.4	90.2	94.6	98.4	100.5
125.00	75.3	76.8	77.6	78.5	79.3	80.2	80.8	81.8	83.1	84.6	86.6	88.6	91.3	95.6	98.9	100.5
160.00	76.3	77.8	78.6	79.5	80.2	81.2	81.8	82.8	84.0	85.5	87.7	89.7	92.4	96.2	98.5	99.5
200.00	76.9	78.4	79.2	80.1	80.8	81.8	82.4	83.4	84.6	86.3	88.3	90.3	93.0	96.2	97.5	98.0
250.00	77.3	78.8	79.6	80.5	81.2	82.2	82.7	83.8	85.0	86.8	88.7	90.7	93.3	96.2	96.5	96.2
315.00	77.4	78.9	79.7	80.6	81.4	82.3	82.9	83.9	85.2	86.9	88.7	90.8	93.3	95.6	95.0	94.1
400.00	77.4	78.9	79.7	80.6	81.3	82.3	82.8	83.9	85.1	86.7	88.6	90.7	93.0	94.7	93.3	92.2
500.00	77.3	78.8	79.6	80.5	81.2	82.2	82.8	83.8	85.0	86.5	88.4	90.6	92.6	93.9	91.7	90.4
630.00	76.8	78.3	79.1	80.0	80.7	81.7	82.2	83.3	84.5	85.9	87.8	90.0	91.7	92.5	90.1	88.4
800.00	76.2	77.7	78.5	79.4	80.1	81.1	81.7	82.7	83.9	85.3	87.2	89.4	90.8	91.1	88.4	86.4
1000.00	75.7	77.2	78.0	78.9	79.6	80.6	81.2	82.2	83.4	84.7	86.7	88.8	89.9	89.8	86.8	84.5
1250.00	75.2	76.7	77.5	78.4	79.1	80.1	80.7	81.7	82.9	84.2	86.1	88.2	89.0	88.5	85.3	82.7
1600.00	74.5	76.0	76.8	77.7	78.4	79.4	80.0	81.0	82.2	83.4	85.4	87.4	88.0	87.0	83.5	80.6
2000.00	73.6	75.1	75.9	76.8	77.5	78.5	79.1	80.1	81.3	82.5	84.4	86.4	86.8	85.5	81.9	78.7
2500.00	72.7	74.2	75.0	75.9	76.6	77.6	78.1	79.2	80.4	81.6	83.5	85.4	85.7	84.1	80.3	76.9
3150.00	71.7	73.2	74.0	74.9	75.7	76.6	77.2	78.2	79.5	80.6	82.5	84.3	84.5	82.6	78.6	74.9
4000.00	70.8	72.3	73.1	74.0	74.7	75.7	76.2	77.3	78.5	79.7	81.5	83.2	83.3	81.0	76.9	73.0
5000.00	69.8	71.3	72.1	73.0	73.8	74.7	75.3	76.3	77.6	78.7	80.5	82.2	82.1	79.6	75.2	71.1
6300.00	68.6	70.1	70.9	71.8	72.5	73.5	74.1	75.1	76.3	77.5	79.3	80.9	80.8	78.0	73.5	69.2
8000.00	67.3	68.8	69.6	70.5	71.2	72.2	72.8	73.8	75.0	76.3	78.1	79.6	79.4	76.5	71.7	67.2
10000.00	66.1	67.6	68.4	69.3	70.0	71.0	71.6	72.6	73.8	75.1	76.9	78.4	78.1	75.0	70.1	65.3
12500.00	64.9	66.4	67.2	68.1	68.8	69.8	70.3	71.4	72.6	73.9	75.8	77.1	76.8	73.6	68.4	63.4
16000.00	63.5	65.0	65.8	66.7	67.5	68.4	69.0	70.0	71.3	72.6	74.5	75.8	75.4	72.0	66.6	61.4
20000.00	62.3	63.8	64.6	65.5	66.3	67.2	67.8	68.8	70.0	71.4	73.3	74.6	74.1	70.5	64.9	59.5

```
1                        6/21/99            ANOPP LEVEL 03/02/11                 PAGE     11

                                             STONE JET NOISE MODULE

                                               INPUT PARAMETERS

     AE     =    .10000000E+01      A1     =    .29528755E+01      A2     =    .00000000E+00      CA     =
.11186327E+04
     DELTA  =    .00000000E+00      DE1    =    .19390000E+01      DH1    =    .19390000E+01      MA     =
.00000000E+00
     M1     =    .10000000E+01      M2     =    .00000000E+00      RHOA   =    .22479463E-02      RHO1   =
.74024738E+00
     RHO2   =    .10000000E+01      RS     =    .10000000E+03      T1     =    .14726330E+01      T2     =
.10000000E+01
     V1     =    .85506174E+00      V2     =    .00000000E+00      IOUT   =      1                IPRINT =      3
     METHOD =      2
     NENG   =      1                SCRNNN =      1                SCRXXX =    XXX                STIME  =
.00000000E+00
     IUNITS =    ENGLISH            SUPER  =      F                CIRCLE =      T                PLUG   =      F



                                                UNIT MEMBERS

                          SFIELD  (FREQ    ) IS ALTERNATE NAME OF SFIELD  (FREQ    )
                          STNTBL  (FSP     ) IS ALTERNATE NAME OF STNTBL  (FSP     )
                          STNTBL  (JDF     ) IS ALTERNATE NAME OF STNTBL  (JDF     )
                          STNJET  (XXX001  ) IS ALTERNATE NAME OF STNJET  (XXX001  )
                          SFIELD  (PHI     ) IS ALTERNATE NAME OF SFIELD  (PHI     )
                          STNTBL  (SDF     ) IS ALTERNATE NAME OF STNTBL  (SDF     )
                          SFIELD  (THETA   ) IS ALTERNATE NAME OF SFIELD  (THETA   )
1                        6/21/99            ANOPP LEVEL 03/02/11                 PAGE     12

                                             STONE JET NOISE MODULE

                                          NOISE DATA FROM MODULE STNJET

        OBSERVER DISTANCE =    100.0     (FT)    REFERENCE LENGTH =   1.718     (FT)    POWER LEVEL =   .0000E+00DB
                                                      SOURCE TIME =   .0000E+00

                                             SUBSONIC CIRCULAR NOZZLE
```

GENERAL NOISE PREDICTION MODULE TEST CASE: OUTPUT FILE

STONE JET NOISE MODULE

```
**************************************************
* TABLE OF SOUND PRESSURE LEVEL VALUES (DECIBELS) *
**************************************************
```

AZIMUTH ANGLE = .00 DEGREES

DIRECTIVITY ANGLE (DEGREES)

1/3 OB CTR FREQ (HERTZ)	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0	160.0
OVERALL	92.0	92.2	92.6	93.1	93.7	94.4	95.3	96.3	97.5	98.7	100.0	101.4	102.8	104.1	105.3	106.2
20.00	64.4	64.6	64.8	65.1	65.5	66.1	66.7	67.5	68.3	69.3	70.4	71.5	74.7	77.8	79.4	80.9
25.00	66.7	66.8	67.1	67.4	67.8	68.4	69.0	69.8	70.6	71.6	72.7	73.8	77.3	81.0	82.8	83.7
31.50	68.9	69.0	69.3	69.6	70.0	70.6	71.2	72.0	72.9	73.9	75.0	76.1	80.1	84.4	86.2	86.6
40.00	71.2	71.3	71.6	71.9	72.3	72.9	73.5	74.3	75.2	76.2	77.2	78.4	82.8	87.9	89.1	89.1
50.00	73.3	73.5	73.7	74.1	74.5	75.1	75.7	76.5	77.4	78.4	79.4	80.6	85.4	90.5	91.4	90.6
63.00	75.2	75.3	75.6	76.0	76.5	77.1	77.8	78.6	79.5	80.5	81.6	82.8	87.7	92.4	92.9	92.1
80.00	76.7	76.8	77.1	77.5	78.0	78.7	79.4	80.3	81.2	82.3	83.4	84.8	89.5	93.6	94.8	93.5
100.00	77.7	77.9	78.2	78.6	79.2	79.8	80.6	81.5	82.5	83.6	84.8	86.4	91.0	94.4	96.0	94.5
125.00	78.7	78.8	79.1	79.6	80.1	80.8	81.6	82.5	83.5	84.6	85.8	87.9	92.5	95.3	97.0	95.2
160.00	79.5	79.7	80.0	80.5	81.0	81.7	82.5	83.4	84.5	85.6	86.8	89.4	93.2	95.8	97.4	95.4
200.00	80.1	80.3	80.6	81.1	81.7	82.4	83.2	84.1	85.2	86.4	87.6	90.4	93.5	95.5	96.7	94.5
250.00	80.5	80.7	81.1	81.5	82.1	82.8	83.7	84.7	85.7	86.9	88.2	91.0	93.4	95.0	95.5	92.7
315.00	80.8	81.0	81.3	81.8	82.4	83.1	84.0	85.0	86.1	87.3	88.6	91.1	92.8	94.0	93.8	90.8
400.00	80.9	81.1	81.4	81.9	82.6	83.3	84.2	85.2	86.3	87.5	88.8	90.9	91.8	92.5	92.0	88.9
500.00	80.8	81.0	81.3	81.8	82.5	83.2	84.1	85.1	86.3	87.5	88.9	90.5	90.7	91.1	90.3	87.1
630.00	80.6	80.8	81.2	81.7	82.3	83.1	84.0	85.0	86.2	87.4	88.8	90.0	89.6	89.5	88.6	85.2
800.00	80.1	80.3	80.7	81.2	81.8	82.7	83.6	84.7	85.8	87.1	88.5	89.3	88.3	87.9	86.8	83.2
1000.00	79.4	79.7	80.0	80.6	81.2	82.1	83.0	84.1	85.3	86.6	88.0	88.5	87.1	86.4	85.1	81.4
1250.00	78.8	79.0	79.4	79.9	80.6	81.4	82.3	83.4	84.7	86.0	87.4	87.6	85.9	85.0	83.4	79.6
1600.00	77.9	78.2	78.5	79.1	79.8	80.6	81.6	82.7	83.9	85.2	86.6	86.6	84.6	83.3	81.5	77.6
2000.00	77.0	77.3	77.6	78.2	78.9	79.7	80.7	81.8	83.1	84.4	85.8	85.5	83.4	81.8	79.8	75.8
2500.00	76.0	76.2	76.6	77.2	77.9	78.8	79.7	80.9	82.1	83.5	84.9	84.5	82.2	80.3	78.1	74.0
3150.00	74.9	75.1	75.5	76.1	76.8	77.6	78.6	79.8	81.0	82.4	83.9	83.4	80.9	78.8	76.3	72.1
4000.00	73.8	74.0	74.4	74.9	75.7	76.5	77.5	78.6	79.9	81.3	82.7	82.2	79.6	77.2	74.5	70.1
5000.00	72.7	72.9	73.3	73.9	74.6	75.4	76.4	77.6	78.8	80.2	81.7	81.0	78.3	75.7	72.8	68.3
6300.00	71.5	71.7	72.1	72.7	73.4	74.2	75.2	76.4	77.7	79.0	80.5	79.8	77.0	74.2	71.1	66.4
8000.00	70.3	70.5	70.9	71.4	72.1	73.0	74.0	75.1	76.4	77.8	79.3	78.6	75.7	72.6	69.2	64.5
10000.00	69.1	69.4	69.8	70.3	71.1	71.9	72.9	74.1	75.3	76.7	78.2	77.4	74.5	71.1	67.5	62.7
12500.00	68.0	68.2	68.6	69.2	69.9	70.8	71.8	72.9	74.2	75.6	77.0	76.3	73.2	69.6	65.8	60.9
16000.00	66.7	66.9	67.3	67.9	68.6	69.5	70.5	71.6	72.9	74.3	75.7	75.0	71.9	68.0	64.0	58.8
20000.00	65.5	65.8	66.2	66.7	67.4	68.3	69.3	70.5	71.7	73.1	74.6	73.8	70.6	66.5	62.3	57.0

```
1                                  6/21/99             ANOPP LEVEL 03/02/11                    PAGE     14


                                                             GENERAL NOISE PREDICTION MODULE


                                                         USER PARAMETER VALUES IN ENGLISH UNITS

  AE         =    .10000000E+01     AP         =    .29528755E+01     CA         =    .11186327E+04     LS         =
.19390000E+01
  RHOA       =    .22479463E-02     RS         =    .10000000E+03     VS         =    .85506174E+00     IOUT       =      1
  IPRINT     =      3               NENG       =      1               SCRNNN     =      1               SCRXXX     =    XXX
  STIME      =    .00000000E+00     IUNITS     =    ENGLISH
  XPARAM(1)  =    .39740000E+00     XPARAM(2)  =    .14674000E+01     XPARAM(3)  =    .14971000E+01     XPARAM(4)  =
.10000000E+01
  XPARAM(5)  =    .10000000E+01

                                                                       UNIT MEMBERS

                                    SFIELD  (FREQ    ) IS ALTERNATE NAME OF SFIELD  (FREQ    )
                                    SFIELD  (THETA   ) IS ALTERNATE NAME OF SFIELD  (THETA   )
                                    SFIELD  (PHI     ) IS ALTERNATE NAME OF SFIELD  (PHI     )
                                    GNP     (XXX001  ) IS ALTERNATE NAME OF GNP     (XXX001  )
                                    TSE     (OAPWL   ) IS ALTERNATE NAME OF TSE     (OAPWL   )
                                    TSE     (PSLFIT  ) IS ALTERNATE NAME OF TSE     (PSLFIT  )
                                    TSE     (DIRFIT  ) IS ALTERNATE NAME OF TSE     (DIRFIT  )
                                    TSE     (RSLFIT  ) IS ALTERNATE NAME OF TSE     (RSLFIT  )
1                                  6/21/99             ANOPP LEVEL 03/02/11                    PAGE     15


                                                             GENERAL NOISE PREDICTION MODULE


****************** DBM INFORMATIVE MESSAGE   76 *** MMOPWD - UNIT GNP      IS BEING CREATED
DYNAMICALLY.******************
                                                              NOISE DATA FROM MODULE GNP

         OBSERVER DISTANCE =    100.0     (FT)    REFERENCE LENGTH =   1.718     (FT)    POWER LEVEL =   143.4    DB
                                                                   SOURCE TIME =   .0000E+00
```

GENERAL NOISE PREDICTION MODULE

****
* TABLE OF SOUND PRESSURE LEVEL VALUES (DECIBELS) *
****

AZIMUTH ANGLE = .00 DEGREES

DIRECTIVITY ANGLE (DEGREES)

1/3 OB CTR FREQ (HERTZ)	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0	160.0
OVERALL	86.8	87.8	88.8	89.6	90.4	91.3	92.8	94.6	96.7	98.9	101.3	103.9	106.6	108.7	109.2	107.7
20.00	58.9	59.8	61.6	64.4	67.5	70.0	71.2	71.9	73.4	76.3	80.7	86.2	92.0	95.9	95.2	88.6
25.00	60.4	61.2	63.0	65.6	68.5	70.9	72.1	73.0	74.5	77.4	81.6	86.8	92.3	96.0	95.4	89.3
31.50	62.1	63.0	64.6	67.1	69.7	71.9	73.2	74.2	75.8	78.7	82.7	87.6	92.8	96.4	96.0	90.5
40.00	64.1	65.0	66.5	68.7	71.0	73.1	74.4	75.6	77.4	80.1	83.9	88.6	93.5	97.1	96.9	92.1
50.00	66.0	66.9	68.3	70.2	72.3	74.2	75.6	77.0	78.9	81.6	85.1	89.5	94.3	97.8	97.9	93.8
63.00	68.0	68.8	70.1	71.8	73.6	75.3	76.9	78.5	80.5	83.1	86.4	90.5	95.0	98.5	99.0	95.5
80.00	70.0	70.8	72.0	73.4	74.9	76.5	78.1	79.9	82.0	84.5	87.6	91.4	95.7	99.1	99.9	97.1
100.00	71.7	72.5	73.6	74.7	76.0	77.4	79.1	81.1	83.3	85.8	88.7	92.2	96.2	99.5	100.4	98.2
125.00	73.1	73.9	75.0	75.9	77.0	78.3	80.0	82.1	84.3	86.8	89.5	92.8	96.5	99.5	100.6	98.8
160.00	74.4	75.2	76.2	77.0	77.9	79.1	80.8	82.9	85.2	87.6	90.2	93.1	96.4	99.1	100.1	98.8
200.00	75.1	76.0	77.0	77.8	78.5	79.6	81.2	83.3	85.6	88.0	90.5	93.1	95.9	98.2	99.0	98.0
250.00	75.6	76.5	77.5	78.3	79.0	80.0	81.5	83.5	85.7	88.1	90.5	92.9	95.2	96.9	97.4	96.6
315.00	75.8	76.8	77.8	78.5	79.2	80.1	81.6	83.4	85.6	88.0	90.4	92.5	94.3	95.4	95.5	94.7
400.00	75.8	76.8	77.9	78.6	79.3	80.2	81.5	83.2	85.3	87.7	90.0	92.0	93.2	93.7	93.4	92.5
500.00	75.7	76.7	77.7	78.5	79.2	80.0	81.3	82.9	85.0	87.3	89.6	91.4	92.2	92.2	91.5	90.5
630.00	75.4	76.4	77.4	78.2	78.9	79.8	80.9	82.5	84.5	86.9	89.1	90.7	91.3	90.9	89.8	88.4
800.00	75.0	76.0	77.0	77.8	78.5	79.3	80.5	82.0	84.0	86.3	88.5	90.0	90.4	89.7	88.2	86.4
1000.00	74.5	75.4	76.5	77.3	78.0	78.8	79.9	81.5	83.4	85.7	87.9	89.3	89.4	88.5	86.8	84.6
1250.00	73.9	74.8	75.8	76.6	77.3	78.1	79.3	80.8	82.8	85.0	87.1	88.4	88.4	87.3	85.3	82.6
1600.00	73.1	74.0	75.0	75.7	76.4	77.2	78.4	79.9	81.9	84.1	86.1	87.2	87.1	85.7	83.4	80.4
2000.00	72.2	73.1	74.1	74.9	75.5	76.3	77.4	79.0	80.9	83.1	85.0	86.0	85.7	84.1	81.4	78.2
2500.00	71.2	72.2	73.2	73.9	74.5	75.3	76.4	77.9	79.8	81.9	83.8	84.7	84.1	82.2	79.3	75.8
3150.00	70.1	71.1	72.1	72.8	73.4	74.1	75.2	76.7	78.5	80.6	82.4	83.2	82.4	80.2	77.0	73.4
4000.00	68.9	69.9	70.9	71.6	72.1	72.8	73.8	75.3	77.1	79.2	80.9	81.5	80.5	78.1	74.7	70.9
5000.00	67.7	68.7	69.7	70.4	70.8	71.5	72.5	74.0	75.8	77.9	79.5	80.0	78.8	76.1	72.6	68.7
6300.00	66.3	67.4	68.4	69.0	69.5	70.1	71.1	72.6	74.4	76.4	78.0	78.4	77.1	74.3	70.5	66.5
8000.00	64.9	65.9	67.0	67.6	68.0	68.6	69.6	71.1	72.9	74.9	76.4	76.8	75.3	72.5	68.6	64.4
10000.00	63.5	64.6	65.6	66.2	66.6	67.2	68.2	69.7	71.5	73.5	75.0	75.2	73.8	70.8	66.9	62.5
12500.00	62.2	63.2	64.2	64.8	65.2	65.7	66.8	68.3	70.1	72.0	73.5	73.7	72.3	69.3	65.2	60.7
16000.00	60.6	61.6	62.6	63.2	63.6	64.1	65.2	66.7	68.5	70.4	71.8	72.1	70.6	67.6	63.4	58.7
20000.00	59.2	60.2	61.2	61.8	62.1	62.7	63.8	65.3	67.1	69.0	70.4	70.5	69.1	66.1	61.8	56.9

APPENDIX IV

ANOPP
WING GEOMETRIC EFFECTS MODULE
THEORETICAL MANUAL

(9 Pages)

WING GEOMETRIC EFFECTS MODULE

INTRODUCTION

The Wing Geometric Effects Module computes the effects of wing shielding and reflection on the propagation of noise from the engine. The wing shielding model employs the Fresnel diffraction theory for a semi-infinite barrier, as described in Beranek (1) and Maekawa (2), with modifications to treat the finite barrier presented by the aircraft wing.

SYMBOLS

A	attenuation, dB
c_∞	ambient speed of sound, m/s (ft/s)
f	frequency, Hz
N	Fresnel number
$<p^2>^*$	mean-square acoustic pressure, re $\rho_\infty^2 c_\infty^4$
x, y, z	coordinate locations
<u>GREEK</u>	
ρ_∞	ambient density, kg/m^3 (slug/ft^3)
<u>SUPERSCRIPT</u>	
*	dimensionless quantity
<u>SUBSCRIPT</u>	
1	source location
O	observer location
r	reference standard sea level
RLE	root leading edge
RTE	root trailing edge
TLE	tip leading edge
TOT	total
TTE	tip trailing edge

WING GEOMETRIC EFFECTS MODULE

INPUT

The values of the wing coordinates are provided by user. The source-to-observer geometry is provided by the Geometry (GEO) Module and the one-third octave band noise levels being propagated to the observer is provided by the Propagation (PRO) Module. The frequency array establishes the independent variable values for the output table.

$(x_{RLE}, y_{RLE}, z_{RLE})$	coordinates of root leading edge
$(x_{RTE}, y_{RTE}, z_{RTE})$	coordinates of root trailing edge
$(x_{TLE}, y_{TLE}, z_{TLE})$	coordinates of tip leading edge
$(x_{TTE}, y_{TTE}, z_{TTE})$	coordinates of tip trailing edge

Independent Variable Array

f	frequency, Hz

Received Noise Data Table

f	frequency, Hz
t	reception time, s
o	observer index
$c_a^*(o)$	speed of sound at the observer, re c_r
$\rho_a^*(o)$	air density at the observer, re ρ_r
$<p^2(f,t,o)>^*$	mean square acoustic pressure, re $\rho_\infty^2 c_\infty^4$

WING GEOMETRIC EFFECTS MODULE

OUTPUT

The output of this module is a table of the mean-square acoustic pressure as a function of frequency, reception time, and observer index corrected for wing geometry effects.

Attenuated Received Noise Data Table

f	frequency, Hz
t	reception time, s
o	observer index
$c_a^*(o)$	speed of sound at the observer, re c_r
$\rho_a^*(o)$	air density at the observer, re ρ_r
$<p^2(f,t,o)>^*$	mean square acoustic pressure, re $\rho_\infty^2 c_\infty^4$

METHOD

Wing Geometry

The wing configuration is described in a local coordinate system with the origin positioned at the engine inlet (Point 1), as shown in Figure 1. The local coordinate system is assumed to be the aircraft location specified in the body coordinate system (see the Geometry Module) for the propagation calculation. The user must specify the coordinates at the wing root leading edge, root trailing edge, tip leading edge, and tip trailing edge, relative to the location of the engine inlet.

Then, the engine inlet and wing coordinates are transformed into a global coordinate system consistent with the observer location on the ground (Point O). This transformation must take into account the aircraft attitude and position at the particular time of the observation.

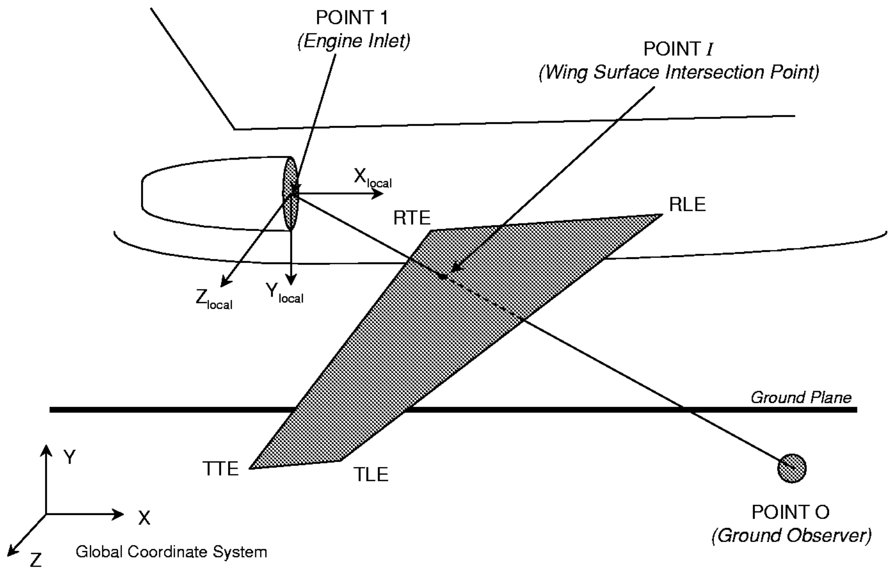


Figure 1. Coordinate system that defines the wing geometry and typical sound propagation vector for wing shielding.

Wing Shielding Model

The location of the point representing the intersection of the line between the engine inlet (Point 1) and the observer on the ground (Point O) with the plane of the wing must be computed. Figure 3.3-1 illustrates the configuration of line 1-O and the wing plane, with the intersection point (Point I). The coordinates of the intersection point are determined by solving a set of three equations in three unknowns (x_I, y_I, and z_I). Two equations are produced by the 2-point form for the equation for the line 1-O:

$$\frac{x_I - x_O}{x_1 - x_O} - \frac{y_I - y_O}{y_1 - y_O} = 0 \tag{1}$$

$$\frac{x_I - x_O}{x_1 - x_O} - \frac{z_I - z_O}{z_1 - z_O} = 0 \tag{2}$$

The other equation comes from the 3-point form of the equation for the wing plane:

$$\begin{vmatrix} x_I - x_{RLE} & y_I - y_{RLE} & z_I - z_{RLE} \\ x_{RTE} - x_{RLE} & y_{RTE} - y_{RLE} & z_{RTE} - z_{RLE} \\ x_{TLE} - x_{RLE} & y_{TLE} - y_{RLE} & z_{TLE} - z_{RLE} \end{vmatrix} = 0 \qquad (3)$$

Because four points have been specified to describe the boundaries of the wing, the wing surface may not actually be planar. However, for the purpose of determining the intersection Point I, the assumption is made that the wing plane is described by the points at the root leading and trailing edges, and the tip leading edge. The intersection point (Point I) may or may not be located within the boundaries of the wing surface.

Now, the point on each wing boundary which is nearest to Point I must be located, as shown in Figure 2. Each of these points (Points W_{LE}, W_{TE}, and W_{TIP}) is computed by solving a set of three equations in three unknowns (e.g., $x_{W_{LE}}$, $y_{W_{LE}}$, and $z_{W_{LE}}$). The equations are obtained by imposing the following conditions:

1) The line I-W must be perpendicular to the wing boundary. This condition is represented by setting the dot product of the line I-W vector and the wing boundary line vector equal to zero, e.g.:

$$\left(x_I - x_{W_{LE}}\right)\left(x_{RLE} - x_{TLE}\right) + \left(y_I - y_{W_{LE}}\right)\left(y_{RLE} - y_{TLE}\right) + \left(z_I - z_{W_{LE}}\right)\left(z_{RLE} - z_{TLE}\right) = 0 \qquad (4)$$

2) The point W must lie on the wing boundary. This condition is met when the coordinates of the point W satisfy the 2-point equation of the line representing the wing boundary edge, e.g.:

$$\frac{x_{W_{LE}} - x_{RLE}}{x_{TLE} - x_{RLE}} - \frac{y_{W_{LE}} - y_{RLE}}{y_{TLE} - y_{RLE}} = 0 \qquad (5)$$

$$\frac{x_{W_{LE}} - x_{RLE}}{x_{TLE} - x_{RLE}} - \frac{z_{W_{LE}} - z_{RLE}}{z_{TLE} - z_{RLE}} = 0 \qquad (6)$$

It is necessary then to determine if the intersection point I actually is located within the boundaries of the wing. If it is outside the wing, then no attenuation of the noise source is present. However, if Point I lies on the wing surface, then the Fresnel diffraction theory is applied to determine the level of attenuation.

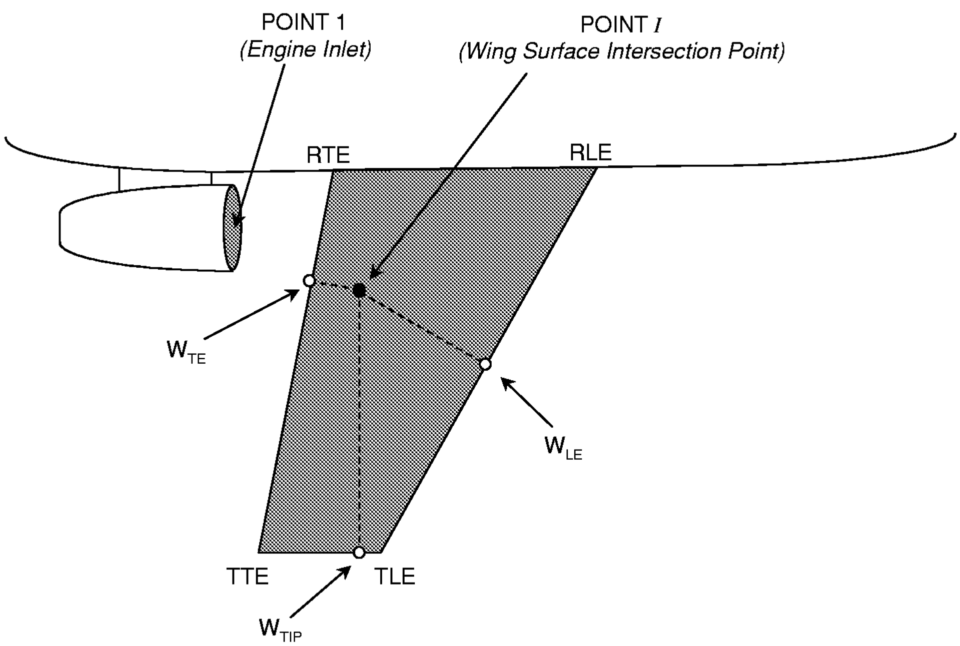


Figure 2. The point that is nearest to the ray intersection point with the wing is determined.

Assuming that Point I is located within the boundaries of the wing, then the attenuation of the noise source due to wing shielding must be determined for each diffraction edge (i.e., wing boundary edge). For each diffraction edge, three distances must be computed, as shown in Figure 3.3-3:

1) The direct source-receiver path length, from Point 1 to Point O, d_{1O},

2) The distance from Point 1 to the closest point on the diffraction edge, Point W, d_{1W},

3) The distance from the point W on the diffraction edge to the observer location on the ground, Point O, d_{WO}.

From these three distances, the difference in source-receiver path length between the direct and diffracted sound fields may be computed:

$$\Delta = (d_{1W} + d_{WO}) - d_{1O} \tag{7}$$

where $\Delta > 0$ when Point I lies on the wing surface, $\Delta = 0$ when Point I lies on the wing boundary edge, and $\Delta < 0$ when Point I is beyond the wing surface.

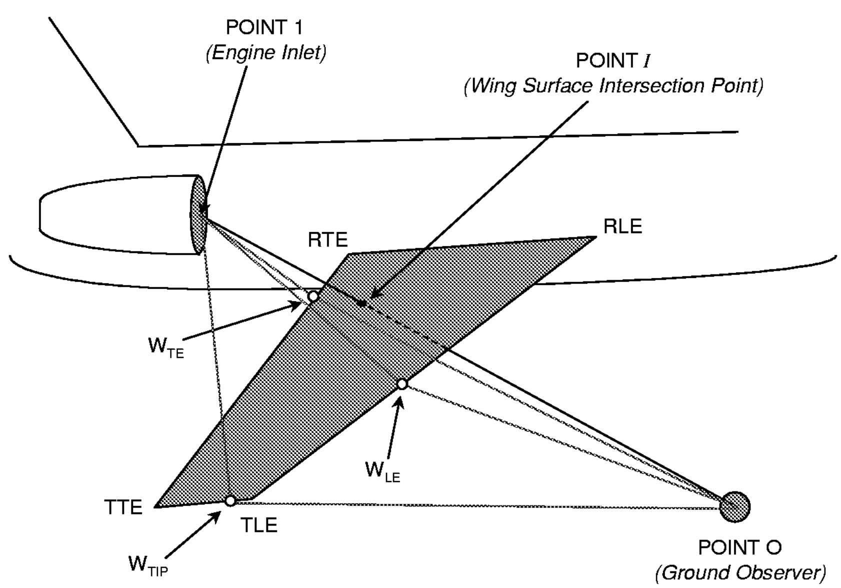


Figure 3. The differences in path length between the direct and diffracted sound rays are used to calculate the wing shielding.

From this difference in distances, the Fresnel number is calculated as follows:

$$N = 2\ f_i\ \Delta\ /\ c_\infty \tag{8}$$

where f_i represents the frequency for each 1/3 octave band, in Hz, and c_∞ represents the ambient speed of sound.

The attenuation is computed for each 1/3 octave band frequency as follows:

$$A(f_i) = \begin{cases} 20\ \log\dfrac{\sqrt{2\pi N}}{\tanh\sqrt{2\pi N}} + 5.0 & ;\ N \geq 0 \\ 20\ \log\dfrac{\sqrt{2\pi|N|}}{\tan\sqrt{2\pi|N|}} + 5.0 & ;\ -0.2 \leq N < 0 \\ 0. & ;\ N < -0.2 \end{cases} \tag{9}$$

This attenuation is the noise reduction due to a semi-infinite barrier. In this model, diffraction around three diffraction edges (wing leading edge, trailing edge, and tip) is included. In order to obtain an equivalent total attenuation from the combined effects of the three diffraction edges, the individual attenuation for each edge at any frequency f_i are combined as follows:

$$A_{TOT} = -10\log\sum 10^{-(A_k/10)} \tag{10}$$

where k = LE, TE, and TIP.

WING GEOMETRIC EFFECTS MODULE

Noise Prediction

The method for the preparation of the output noise results is as follows:

1. Obtain the geometry and received spectra data from the input files.
2. For each reception time value, calculate the point I and determine if the ray intersects the wing.
3. Compute the shielding attenuation using equation (10) at the desired values of frequency.
4. Apply the attenuation to the appropriate value of the received mean-square pressure.

The output values are the attenuated mean-square acoustic pressure values as a function of frequency, reception time, and observer position.

REFERENCES

1. Beranek, L.L., Noise and Vibration Control, McGraw-Hill Book Company, 1971, pp. 174-180.

2. Maekawa, Z., "Noise Reduction By Screens," Applied Acoustics, Elsevier Publishing Co., Ltd., 1968, pp. 157-173.

APPENDIX V

ANOPP
WING GEOMETRIC EFFECTS MODULE
USER'S MANUAL

(3 Pages)

WING GEOMETRIC EFFECTS MODULE

```
***
*       PURPOSE - WING TAKES NOISE DATA WHICH HAS BEEN PROPAGATED TO THE
*                 OBSERVER BY THE PROPAGATION (PRO) MODULE
*                 AND APPLIES CORRECTIONS FOR WING GEOMETRY EFFECTS.
*
*       AUTHOR  - DSW(L03/02/11)
*
*       INPUT
*         USER PARAMETERS
*           METHOD     OPTION FLAG FOR METHOD TO BE APPLIED
*                      =1  WING SHIELDING AND DIFFRACTION
*                      =2  WING REFLECTION (TO BE PROVIDED)
*           IPRINT     OUTPUT PRINT OPTION CODE  (INTEGER)
*                      =0 NO PRINTED OUTPUT
*                      =1 PRINT INPUT DATA ONLY
*                      =2 PRINT OUTPUT DATA ONLY
*                      =3 PRINT BOTH INPUT AND OUTPUT DATA (DEFAULT)
*           IUNITS     =2HSI     , INPUTS ARE IN SI UNITS (DEFAULT)
*                      =7HENGLISH, INPUTS ARE IN ENGLISH UNITS
*           ROOTLE(3)  THREE ELEMENT PARAMETER WITH THE X,Y,Z
*                      COORDINATES OF THE WING ROOT LEADING EDGE (3RS)
*           ROOTTE(3)  THREE ELEMENT PARAMETER WITH THE X,Y,Z
*                      COORDINATES OF THE WING ROOT TRAILING EDGE (3RS)
*           TIPLE(3)   THREE ELEMENT PARAMETER WITH THE X,Y,Z
*                      COORDINATES OF THE WING TIP LEADING EDGE (3RS)
*           TIPTE(3)   THREE ELEMENT PARAMETER WITH THE X,Y,Z
*                      COORDINATES OF THE WING TIP TRAILING EDGE (3RS)
*         DATA BASE UNITS AND MEMBERS
*           GEO(BODY)       GEOMETRY DATA FOR ALL OBSERVERS RELATIVE
*                           TO THE AIRCRAFT BODY COORDINATE SYSTEM
*                             SEE DESCRIPTION IN DATA BASE STRUCTURES.
*                             (SEE MODULE GEO)
*           PRO(PRES)       DIMENSIONLESS MEAN SQUARE PRESSURE AT THE
*                           OBSERVER AS A FUNCTION OF FREQUENCY AND
*                           TIME. (SEE DESCRIPTION IN DATA BASE
*                           STRUCTURES.)
*      OUTPUT
*         USER PARAMETERS
*           NERR            =.TRUE. , ERROR ENCOUNTERED, PRO
*                           TERMINATED ABNORMALLY
*                           =.FALSE., NO ERRORS ENCOUNTERED, PRO
*                           TERMINATED SUCCESSFULLY
*
*         DATA BASE UNITS AND MEMBERS
*           WING(PRES)      DIMENSIONLESS MEAN SQUARE PRESSURE AT THE
*                           OBSERVER, CORRECTED FOR WING EFFECTS
*                           AS A FUNCTION OF FREQUENCY AND
*                           TIME. (SEE DESCRIPTION IN DATA BASE
*                           STRUCTURES.)
*       DATA BASE STRUCTURES
*         THE FORMAT OF GEO(BODY) IS AS FOLLOWS:
*
*            RECORD   WORD                 DESCRIPTION
*              1             RECORD FORMAT IS I,3RS,I,RS
*                        1    OBSERVER INDEX FOR FIRST OBSERVER
*                        2    X COORDINATE OF OBSERVER
*                        3    Y COORDINATE OF OBSERVER
*                        4    Z COORDINATE OF OBSERVER
*                        5    NUMBER OF RECEPTION TIMES ASSOCIATED WITH
*                             THIS OBSERVER (ASSUME VALUE IS N)
*                        6    OBSERVER'S HEIGHT
```

```
*
*          2             RECORD FORMAT IS *RS
*                   1
*                   .    RECEPTION TIMES FOR CURRENT OBSERVER
*                   .    INDEX
*                   N
*
*          RECORDS 3 THROUGH  N+2  CONTAIN GEOMETRY DATA FOR EACH
*          RECEPTION TIME.  RECORD 3 CONTAINS GEOMETRY DATA FOR
*          THE FIRST RECEPTION TIME, RECORD 4 FOR THE SECOND
*          RECEPTION TIME,... RECORD N+2 FOR THE N TH RECEPTION
*          TIME.
*
*           3            RECORD FORMAT IS *RS
*                   1    DISTANCE OF SOURCE FROM OBSERVER
*                   2    EMISSION TIME, SEC
*                   3    DIRECTIVITY ANGLE, DEG
*                   4    ELEVATION ANGLE, DEG
*                   5    AZIMUTH ANGLE, DEG
*
*           4       REPEAT OF RECORD 3 FOR SECOND RECEPTION TIME
*           .       .
*           .       .
*          N+3           RECORD FORMAT IS I,3RS,I,RS
*                   1    OBSERVER INDEX FOR SECOND OBSERVER
*                   2    X COORDINATE OF OBSERVER
*                   3    Y COORDINATE OF OBSERVER
*                   4    Z COORDINATE OF OBSERVER
*                   5    NUMBER OF RECEPTION TIMES ASSOCIATED WITH
*                        THIS OBSERVER (ASSUME VALUE IS M)
*
*          N+4           RECORD FORMAT IS *RS
*                   1
*                   .    RECEPTION TIMES FOR CURRENT OBSERVER
*                   .    INDEX
*                   M
*          RECORD  N+5 THROUGH RECORD N+M+4 CONTAIN GEOMETRY DATA
*          FOR EACH RECEPTION TIME STORED IN THE SAME MANNER AS
*          DESCRIBED ABOVE IN RECORDS 3 THROUGH N+2.
*
*         THE PATTERN AS SEEN IN RECORDS 1 THROUGH N+2 AND RECORDS
*         N+3 THROUGH N+M+4 CONTINUES FOR ALL OBSERVERS
**
*     THE FORMAT OF PRO(PRES) AND WING (PRES) IS AS FOLLOWS:
*
*        RECORD    WORD                DESCRIPTION
*          1             RECORD FORMAT IS I,*A8
*                   1    NUMBER OF NOISE SOURCES PROPAGATED TO
*                        THE OBSERVERS, NS.
*              2-(NS+1)  MODULE NAMES OF NOISE SOURCES PROPAGATED
*                        TO THE OBSERVERS
*
*          2             RECORD FORMAT IS 2I,2RS
*                   1    OBSERVER INDEX FOR THE FIRST OBSERVER
*                   2    NUMBER OF RECEPTION TIMES ASSOCIATED WITH
*                        THIS OBSERVER (ASSUME VALUE IS N)
*                   3    AIR DENSITY AT THE OBSERVER  (RE RHO )
*                                                            R
*                   4    SPEED OF SOUND AT THE OBSERVER (RE C )
*                                                            R
*          3             RECORD FORMAT IS *RS
```

```
*                       1
*                       .    RECEPTION TIMES FOR CURRENT OBSERVER
*                       .    INDEX
*                       N
*
*              4             RECORD FORMAT IS *RS
*                       1    DIMENSIONLESS MEAN SQUARE PRESSURE FOR
*                            THE FIRST FREQUENCY AND THE FIRST
*                            RECEPTION TIME
*                       2    DIMENSIONLESS MEAN SQUARE PRESSURE FOR
*                            THE SECOND FREQUENCY AND THE FIRST
*                            RECEPTION TIME
*                       .
*                       .
*                      NF    DIMENSIONLESS MEAN SQUARE PRESSURE FOR
*                            THE LAST FREQUENCY AND THE FIRST
*                            RECEPTION TIME
*
*              5             RECORD FORMAT IS *RS
*                       1    DIMENSIONLESS MEAN SQUARE PRESSURE FOR
*                       .    ALL FREQUENCIES FOR THE SECOND
*                       .    RECEPTION TIME
*                      NF
*
*              6             RECORD FORMAT IS *RS
*                       1    DIMENSIONLESS MEAN SQUARE PRESSURE FOR
*                       .    ALL FREQUENCIES FOR THE THIRD
*                       .    RECEPTION TIME
*                      NF
*              .
*              .
*             N+4      SAME AS RECORD 2 BUT DATA IS FOR SECOND
*                      OBSERVER
*
*             N+5      SAME AS RECORD 3 BUT DATA IS FOR SECOND
*                      OBSERVER
*
*             RECORDS 2 THROUGH N+3 REPEAT FOR ALL OBSERVERS.  THE
*             VALUE OF N DIFFERS FOR EACH OBSERVER.
*
*         ERRORS
*           NON-FATAL
*             FUNCTIONAL MODULE ERRORS
*               1. REQUIRED UNIT MEMBER NOT AVAILABLE
*               2. INSUFFICIENT LDS DYNAMIC STORAGE
*               3. UNIT MEMBER NOT OF CORRECT FORMAT
*               4. MEMBER MANAGER ERROR OCCURRED ON READING OR OPENING
*                  A UNIT MEMBER
*               7. ERROR ENCOUNTERED IN BUILDING A UNIT MEMBER
**
*           FATAL - NONE
*
*         LDS REQUIREMENTS
*
*           LENGTH = 3*NFREQ
*
*                    WHERE NFREQ = NUMBER OF FREQUENCIES
*
*         GDS REQUIREMENTS - NONE
*
***
```

APPENDIX VI

ANOPP
WING GEOMETRIC EFFECTS MODULE
TEST CASE INPUT AND OUTPUT

(25 Pages)

WING GEOMETRIC EFFECTS MODULE TEST CASE:
INPUT FILE

```
ANOPP JECHO=.FALSE. JLOG=.FALSE. NLPPM=60 $
  STARTCS $
  SETSYS JECHO=.FALSE. $
  $
  $
  $  THIS JOB COMPUTES THE CERTIFICATION NOISE LEVELS FOR THE 1992
  $  AST TECHNOLOGY BASELINE BUSINESS JET.  THE INPUT
  $  DECK IS SET UP TO TAKE INPUT PARAMETERS THAT MATCH THE INPUT
  $  TO THE GASP PROGRAM TO MAKE IT EASY TO TRANSFER DATA FROM THE
  $  GASP INPUT DECK TO THE ANOPP JOB STREAM.  FURTHER EXPLANATION
  $  OF HOW THIS WORKS WILL BE PROVIDED AS THE DATA ARE ENTERED.
  $
  $
  $  THE FIRST STEP IS TO ENTER THE GASP NAMLIST DATA.  EVERY EFFORT
  $  IS MADE TO KEEP THE DATA IN CONSISTENT FORMAT WITH GASP.
  $
  $
  $  NAMELIST "CONT" IS ENTERED FIRST
  $
  $
  PARAM IFAA     = 1         $  CURRENTLY, ONLY OPTIONS 1-4 (APPROACH,
                             $  TAKEOFF, SIDELINE, AND LEVEL FLIGHT) ARE
                             $  VALID OPTIONS
  PARAM ISI      = 0         $  SELECT ENGLISH OR SI UNITS
  $
  $
  $  NOW, NAMELIST "ENV" IS ENTERED
  $
  $
  PARAM TAMB     = 536.67    $  AMBIENT TEMPERATURE, DEG R
  PARAM PAMB     = 2116.22   $  AMBIENT PRESSURE, PSF
  PARAM RH       = 70.       $  RELATIVE HUMIDITY, PERCENT
  PARAM DIST     = 100.      $  DISTANCE FOR STATIC PREDICTIONS, FT
  $
  $
  $  THE ANGLE ARRAY IS NOT ENTERED AS A USER PARAMETER, BUT AS A UNIT
  $  MEMBER (FILE) ALONG WITH THE DESIRED FREQUENCIES AS FOLLOWS:
  $
  $
  UPDATE NEWU=SFIELD SOURCE=* $
  -ADDR OLDM=* NEWM=FREQ  FORMAT=4H*RS$ $  1/3 OCTAVE CENTER FREQUENCIES
                                          50.   63.   80.   100.
      125.  160.  200.  250.  315.  400.  500.  630.  800.  1000.
     1250. 1600. 2000. 2500. 3150. 4000. 5000. 6300. 8000. 10000. $
  -ADDR OLDM=* NEWM=THETA FORMAT=4H*RS$ $  POLAR DIRECTIVITY ANGLES
      10. 20. 30. 40. 50. 60. 70. 80. 90. 100. 110. 120. 130. 140.
     150. 160. $
  -ADDR OLDM=* NEWM=PHI   FORMAT=4H*RS$ $ AZIMUTH DIRECTIVITY ANGLES
       0. $  SOURCES ARE AXISYMMETRIC
  END* $
  $
  $
  $  IN ADDITION, THE TEMPERATURE AND RELATIVE HUMIDITY MUST BE ENTERED
  $  AS A UNIT MEMBER (FILE) BECAUSE ANOPP ASSUMES YOU ALWAYS WANT TO
  $  USE A LAYERED ATMOSPHERE
  $
  $
```

WING GEOMETRIC EFFECTS MODULE TEST CASE:
INPUT FILE

```
UPDATE NEWU=ATM SOURCE=* $
-ADDR OLDM=* NEWM=IN FORMAT=4H3RS$ $
     0.  536.67 70.  $  ALTITUDE, TEMPERATURE, RELATIVE HUMIDITY
END* $                  (ONLY ONE RECORD IS NEEDED FOR UNIFORM ATMOSPHERE)
$
$
$  THE NAMELIST VARIABLES FOR "SYS" ARE ENTERED NEXT
$
$
PARAM NTYE     = 1         $  ONLY CURRENT OPTION IS TURBOJET (OR MIXED
                           $  STREAM TURBOFAN)
PARAM ICOMP    = 1,4,5     $  ONLY CURRENT OPTIONS ARE FAN, COMBUSTOR,
                           $  OR JET
PARAM ENP      = 2.        $  NUMBER OF ENGINES
PARAM ANENGI   = 0.        $  ANGLE BETWEEN ENGINE INLET AND AIRCRAFT,
                           $  DEGREES
PARAM ANENGE   = 0.        $  ANGLE BETWEEN ENGINE EXHAUST AND AIRCRAFT,
                           $  DEGREES
PARAM WGMAX    = 28700.    $  AIRCRAFT MAX. GROSS WEIGHT AT T/O, LB
PARAM AMACH    = 0.2086    $  AIRCRAFT MACH NUMBER (CAN ALSO SPECIFY
                           $  PARAMETER "VEL" IN FT/SEC)
$
$
$  THE VARIABLES LOCENG, XL, YL, ZL, IPHASE, AND IDOP ARE NOT
$  APPLICABLE TO THE CURRENT ANOPP MODEL
$
$
$  THE NAMELIST "FPRO" IS ENTERED NEXT
$
$
PARAM IDPRO    = 0         $  STRAIGHT LINE PROFILE (USER CAN ALSO
                           $  SPECIFY PROFILE USING UNIT MEMBER)
PARAM FLTANG   = -3.0      $  FLIGHT PATH ANGLE, DEGREES
PARAM ANGAFT   = 4.2       $  AIRCRAFT ANGLE OF ATTACK, DEGREES
PARAM TOROLL   = 4921.3    $  LENGTH OF TAKEOFF ROLL, FT
PARAM APDIST   = 10685.    $  INITIAL AIRCRAFT APPROACH RANGE, FT
PARAM XALT     = 1000.     $  AIRCRAFT ALTITUDE FOR LEVEL FLYOVER, FT
$
$
$  NOW THE ENGINE THERMODYNAMIC DATA ARE ENTERED.  NAMELIST "FAN" FOR
$  PREDICTING FAN NOISE IS ENTERED FIRST
$
$
PARAM IGV      = 0         $  FAN HAS NO INLET GUIDE VANES
PARAM NBF      = 30        $  NUMBER OF FAN BLADES
PARAM NVAN     = 61        $  NUMBER OF STATOR VANES
PARAM RSS      = 170.      $  ROTOR/STATOR SPACING IN
PARAM WAFAN    = 91.455    $  FAN INLET WEIGHT FLOW, LB/S
PARAM RPM      = 6982.     $  FAN PHYSICAL SPEED, RPM
PARAM FPR      = 1.239     $  FAN PRESSURE RATIO
PARAM FANDIA   = 2.455     $  FAN DIAMETER, FT
PARAM TIPMD    = 1.446     $  FAN TIP MACH NUMBER AT DESIGN POINT
PARAM FANEFF   = 0.8104    $  FAN EFFICIENCY
$
$
$  NOW NAMELIST "BURNER" FOR THE COMBUSTOR
$
```

WING GEOMETRIC EFFECTS MODULE TEST CASE: INPUT FILE

```
$
PARAM WACOMB   = 14.310    $  COMBUSTOR WEIGHT FLOW, LB/S
PARAM T3       = 1002.9    $  COMBUSTOR INLET TEMPERATURE, DEG R
PARAM T4       = 2074.9    $  COMBUSTOR EXIT TEMPERATURE, DEG R
PARAM P3       = 13737.3   $  COMBUSTOR INLET TOTAL PRESSURE, PSF
$
$
$  AND FINALLY "JET" FOR THE MIXED STREAM JET NOISE
$
$
PARAM VJ       = 692.4     $  FULLY EXPANDED JET VELOCITY, FPS
PARAM TJ       = 754.3     $  JET TOTAL TEMPERATURE, DEG R
PARAM DJ       = 1.8507    $  JET OUTER DIAMETER, FT
PARAM GAMJ     = 1.333     $  JET RATIO OF SPECIFIC HEATS
$
$
$  THERE ARE MANY ADDITIONAL PARAMETERS AND NAMELISTS FOR GASP.  HOWEVER,
$  THEY ARE NOT RELEVANT TO ANOPP CABABILITIES OR HAVE NOT BEEN IMPLEMENTED
$  IN THIS JOB STREAM.  THE REMAINING STATEMENTS ARE REQUIRED TO CONVERT
$  TO ANOPP INPUT AND TO EXECUTE THE ANOPP MODULES.  THEY NEED NEVER BE
$  CHANGED UNLESS THE JOB STREAM CAPABILITY IS MODIFIED.
$
$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$
$  CONVERSION OF GASP USER PARAMETERS TO ANOPP INPUT
$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$
$
$  FIRST, THE OBSERVER POSITIONS CORRESPONDING TO THE FOUR FAR 36 FLIGHT
$  PROFILES ARE DEFINED
$
$
IF ( IFAA .GT. 1 ) GOTO A1 $
$
$
$  APPROACH OBSERVER COORDINATES
$
$
UPDATE NEWU=OBSERV SOURCE=* $
-ADDR OLDM=* NEWM=COORD FORMAT=4H3RS$ $
     -7516.  0.  4.  $
END* $
GOTO A4 $
$
A1 CONTINUE $
IF ( IFAA .GT. 2 ) GOTO A2 $
$
$
$  TAKEOFF OBSERVER COORDINATES
$
$

UPDATE NEWU=OBSERV SOURCE=* $
  -ADDR OLDM=* NEWM=COORD FORMAT=4H3RS$ $
       21325.  0.  4.  $
```

WING GEOMETRIC EFFECTS MODULE TEST CASE:
INPUT FILE

```
END* $
GOTO A4 $
$
A2 CONTINUE $
IF ( IFAA .GT. 3 ) GOTO A3 $
$
$
$  SIDELINE OBSERVER COORDINATES
$
$
UPDATE NEWU=OBSERV SOURCE=* $
-ADDR OLDM=* NEWM=COORD FORMAT=4H3RS$ $
      6000. 1476.  4.  $
      7000. 1476.  4.  $
      8000. 1476.  4.  $
      9000. 1476.  4.  $
     10000. 1476.  4.  $
     11000. 1476.  4.  $
END* $
GOTO A4 $
$
A3 CONTINUE $
$
$
$  LEVEL FLYOVER OBSERVER COORDINATES
$
$
UPDATE NEWU=OBSERV SOURCE=* $
-ADDR OLDM=* NEWM=COORD FORMAT=4H3RS$ $
         0.  0.  4.  $
END* $
A4 CONTINUE $
$
$
$  NOW SOME STANDARD CONTROL PARAMETERS ARE DEFINED
$
$
PARAM    PIE    = 3.14159  $  VALUE OF PI
PARAM    AE     = 1.       $  SET REFERENCE AREA TO ONE SQUARE FOOT
PARAM    RS     = DIST     $  SET SOURCE RADIUS DISTANCE INPUT VALUE
PARAM    TA     = TAMB     $  DEFINE AMBIENT TEMPERATURE
EVALUATE RHOA   = PAMB / TAMB / 1716.22
                           $  COMPUTE AMBIENT DENSITY
EVALUATE CA     = 1116.22 * SQRT ( TAMB / 518.67 )
                           $  COMPUTE AMBIENT SPEED OF SOUND
EVALUATE NENG   = INT ( ENP )
                           $  MAKE ENGINE NUMBER INTEGER
PARAM    MA     = AMACH    $  DEFINE MACH NUMBER
PARAM    IOUT   = 1        $  PRINT DB VALUES ONLY
IF ( ISI .NE. 0 ) GOTO B1  $  SET UNITS FLAG
PARAM   IUNITS  = 7HENGLISH $
GOTO B2 $
B1 CONTINUE $
PARAM   IUNITS  = 2HSI $
B2 CONTINUE $
$
$
```

WING GEOMETRIC EFFECTS MODULE TEST CASE:
INPUT FILE

```
$  THE ENGINE PARAMETERS ARE CONVERTED TO ANOPP FORM
$
$  FIRST, THE FAN
$
$
EVALUATE AFAN   = PIE * FANDIA**2 / 4.
                           $  COMPUTE FAN REFERENCE AREA
PARAM    DIAM   = FANDIA   $  DEFINE FAN DIAMETER
PARAM    MD     = TIPMD    $  DEFINE TIP MACH NUMBER AT DESIGN POINT
EVALUATE RSS    = RSS / 100.
                           $  CONVERT ROTOT/STATOR SPAVING TO RATIO
EVALUATE MDOT   = WAFAN / 32.17 / RHOA / CA
                           $  NORMALIZE WEIGHT FLOW
EVALUATE DELTAT = ( FPR**0.2857 - 1. ) / FANEFF
                           $  COMPUTE FAN TEMPERATURE RISE
PARAM    NB     = NBF      $  SET NUMBER OF BLADES
PARAM    NV     = NVAN     $  SET NUMBER OF VANES
EVALUATE IGV    = IGV + 1  $  SET IGV FLAG
EVALUATE N      = ( RPM / 60. ) * DIAM / CA
                           $  COMPUTE NORMALIZED ROTATIONAL SPEED
PARAM    INCT   = .FALSE.  $  TURN OFF COMBINATION TONES
$
$
$  NOW THE COMBUSTOR
$
$
EVALUATE A      = 0.1 * AFAN
                          $  ARBITRARY AREA DEFINED
EVALUATE MDOTC  = WACOMB / 32.17 / RHOA / CA
                          $  WEIGHT FLOW NORMALIZED (NOTE: ANOPP USES
                          $  "MDOT" FOR BOTH THE FAN AND COMBUSTOR -
                          $  COMBUSTOR MASS FLOW IS RENAMED TO AVOID
                          $  OVERWRITE
EVALUATE PI     = P3 / PAMB
                          $  NORMALIZE INPUT PRESSURE
EVALUATE TI     = T3 / TAMB
                          $  NORMALIZE INPUT TEMPERATURE
EVALUATE TCJ    = T4 / TAMB
                          $  NORMALIZE OUTPUT TEMPERATURE
PARAM    TDDELT = 1.0     $   USE THIS PARAMETER - SET TO 1
$
$
$  JET PARAMETERS
$
$
EVALUATE AJ     = PIE * DJ ** 2 / 4.
                          $  COMPUTE JET AREA
EVALUATE TJ     = TJ / TAMB
                          $  NORMALIZE JET TOTAL TEMPERATURE
EVALUATE VJ     = VJ / CA $  NORMALIZE JET VELOCITY
EVALUATE RHOJ   = 1. / ( TJ - ( GAMJ - 1 ) / 2. * VJ**2 )
                          $  COMPUTE NORMALIZED JET DENSITY
PARAM    CIRCLE = .TRUE.  $  REQUEST SINGLE JET FORM STONE'S METHOD
$
$
$  LOAD UNITS FROM DATA LIBRARY
$
```

WING GEOMETRIC EFFECTS MODULE TEST CASE:
INPUT FILE

```
$
LOAD /LIBRARY/ SAE PROCLIB STNTBL $
$
$
$  PREDICT SOURCE NOISE
$
$
PARAM IDBB = .FALSE. $
PARAM IDRS = .FALSE. $
EXECUTE HDNFAN HDNFAN=FANIN $
PARAM IDBB = .TRUE. $
PARAM IDRS = .TRUE. $
PARAM INRS = .FALSE. $
PARAM INDIS = .FALSE. $
PARAM INBB = .FALSE. $
EXECUTE HDNFAN HDNFAN=FANOUT $
EVALUATE RS = DIST * SQRT ( 10. ) $
EXECUTE GECOR MDOT=MDOTC $
PARAM    RS = DIST $
EXECUTE SGLJET $
$$$$$ EXECUTE STNJET A1=AJ DE1=DJ DH1=DJ V1=VJ T1=TJ RHO1=RHOJ $
$
$
$  NOW, THE ATMOSPHERIC CONDITIONS AND THE ATMOSPHERIC ABSORPTION
$  COEFFICIENTS ARE COMPUTED
$
$
EXECUTE ATM P1=PAMB $
EXECUTE ABS $
$
$
$  THE FLIGHT PATH AND GEOMETRY IS NOW DEFINED
$
$
EVALUATE VA     = AMACH * CA $  DEFINE AIRCRAFT SPEED
IF ( IFAA .GT. 1 ) GOTO C1 $
EVALUATE XA     = 0. - APDIST
                             $  DEFINE STARTING DISTANCE FOR APPROACH
EVALUATE ZA     = - APDIST * SIN ( FLTANG )
                             $  DEFINE ALTITUDE AT BEGINNING OF APPROACH
EVALUATE THW    = 0. - FLTANG
                             $  DEFINE FLIGHT PATH ANGLE
PARAM    PLG    = 4HDOWN     $  LANDING GEAR IS DOWN
PARAM    TLG    = -1.        $  LANDING GEAR CHANGED BEFORE START
PARAM    JF     = 200        $  ALLOW 200 TIME STEPS
PARAM    ZF     = 0.         $  STOP AT TOUCHDOWN
PARAM    START  = 0.         $  START EPNL CALCULATION
PARAM    STOP   = 80.        $  STOP EPNL CALCULATION
GOTO C3 $
C1 CONTINUE $
IF ( IFAA .GT. 3 ) GOTO C2 $
PARAM    XA     = TOROLL
                               $  DEFINE STARTING DISTANCE FOR TAKEOFF
PARAM    ZA     = 0.
                               $  DEFINE ALTITUDE AT BEGINNING OF TAKEOFF
PARAM    THW    = FLTANG
                               $  DEFINE FLIGHT PATH ANGLE
```

**WING GEOMETRIC EFFECTS MODULE TEST CASE:
INPUT FILE**

```
PARAM    PLG    = 4HUP        $  LANDING GEAR IS UP
PARAM    TLG    = -1.         $  LANDING GEAR CHANGED BEFORE START
PARAM    JF     = 200         $  ALLOW 200 TIME STEPS
PARAM    ZF     = 32000.      $  STOP AT 32000. FT
PARAM    XF     = 32000.      $
GOTO C3 $
C2 CONTINUE $
EVALUATE XA     = XALT * SIN ( -5. )
                             $  DEFINE STARTING DISTANCE FOR LEVEL FLIGHT
PARAM    ZA     = XALT
                             $  DEFINE ALTITUDE FOR LEVEL FLYOVER
PARAM    THW    = 0.
                             $  DEFINE FLIGHT PATH ANGLE
PARAM    PLG    = 4HUP       $  LANDING GEAR IS UP
PARAM    TLG    = -100.      $  LANDING GEAR CHANGED BEFORE START
PARAM    JF     = 200        $  ALLOW 200 TIME STEPS
EVALUATE XF     = 0. - XA    $  STOP AT SAME DISTANCE FROM MIC.
PARAM    START  = -9999.     $  SET ARBITRARY START TIME
C3 CONTINUE $
PARAM    ALPHA  = ANGAFT     $  SET ANGLE OF ATTACK
PARAM    ENGNAM = 3HXXX      $  SET DEFAULT ENGINE NAME IN SFO
PARAM    ICOORD = 1          $  REQUEST BODY AXIS
$
$
$  NOW GENERATE GEOMETRY
$
$
PARAM IPRINT = 1 $  PRINT INPUT ONLY
$
EXECUTE SFO VI=VA XI=XA ZI=ZA VF=VA $
EXECUTE GEO $
$
$
$  NOW ENTER PROPAGATION PARAMETERS
$
$
PARAM    NCOMP  = 1      $  NUMBER OF NOISE COMPONENTS TO BE PROPAGATED
PARAM    ABSORP = .TRUE. $  INCLUDE ABSORPTION
PARAM    GROUND = .TRUE. $  INCLUDE GROUND EFFECTS
PARAM    PROSUM = 6HFANIN
                         $  FOUR NOISE SOURCES
PARAM    IOSPL  = .TRUE. $  COMPUTE OVERALL SPL
PARAM    IAWT   = .TRUE. $  COMPUTE A-WEIGHTED OASPL
PARAM    IPNL   = .TRUE. $  COMPUTE PNL
PARAM    PROPRT = 1      $  ONLY PRINT PROPAGATION MODULE INPUT
PARAM    LEVPRT = 1      $  ONLY PRINT NOISE LEVELS MODULE INPUT
PARAM    EFFPRT = 1      $  ONLY PRINT EFFECTIVE NOISE MODULE INPUT
$
$
$  UNIT FLI MUST BE MODIFIED TO SET ONLY ONE SOURCE TIME
$
$
UPDATE NEWU=FLIMOD OLDU=FLI ALL SOURCE=* $
   -OMIT FLIXXX $
   -ADDR OLDM=* NEWM=FLIXXX FORMAT=11H6RS,A4,2RS$ $
        0. 0.2 1. 1116. .00238 .1 4HUP   0. 0. $
END* $
```

WING GEOMETRIC EFFECTS MODULE TEST CASE:
INPUT FILE

```
$
$
$  AND CALL PROPAGATION MODULE
$
$
$
EXECUTE PRO GEOM=BODY FLI=FLIMOD $
$
PARAM ROOTLE = 10.4, 2.2, -1.6 $  ROOT LEADING EDGE
PARAM ROOTTE = -0.3, 2.2, -1.6 $  ROOT TRAILING EDGE
PARAM TIPLE  =  0.8, 1.1, 20.8 $  TIP LEADING EDGE
PARAM TIPTE  = -2.6, 1.1, 20.8 $  TIP TRAILING EDGE
PARAM IPRINT = 3 $
$
EXECUTE WING $
$
$
$  END OF JOB
$
$
ENDCS $
```

```
  NNNN      NNNN        NNNN        NNNNNNNNNNNN        NNNN
NNNNNNNN    NNNN      NNNNNNNN     NNNNNNNNNNNNN      NNNNNNNN
NNNN NNNN   NNNN     NNNN  NNNN   NNNN               NNNN  NNNN
NNNN NNNN   NNNN     NNNN  NNNN   NNNN               NNNN  NNNN
NNNN  NNNN  NNNN    NNNN    NNNN   NNNNNNNNNNN      NNNN    NNNN
NNNN  NNNN  NNNN    NNNN    NNNN    NNNNNNNNNNN     NNNN    NNNN
NNNN   NNNN NNNN   NNNN      NNNN           NNNN   NNNN      NNNN
NNNN   NNNN NNNN   NNNN      NNNN           NNNN   NNNN      NNNN
NNNN    NNNNNNNN  NNNN        NNNNNNNNNNNNNNNNN   NNNN        NNNN
NNNN      NNNN    NNNN        NNNNNNNNNNNNNNNN    NNNN        NNNN
```

```
  NNNNNNNNNNNN    NNNN        NNNN    NNNNNNNNNNNN    NNNNNNNNNNNNNN    NNNNNNNNNNNNNN
 NNNNNNNNNNNNNN   NNNN        NNNN   NNNNNNNNNNNNNN   NNNNNNNNNNNNNNN   NNNNNNNNNNNNNNN
NNNNNNNNNNNNNNNN  NNNNN       NNNN  NNNNNNNNNNNNNNNN  NNNNNNNNNNNNNNNN  NNNNNNNNNNNNNNNN
NNNNN      NNNNN  NNNNNN      NNNN  NNNNN      NNNNN  NNNN       NNNNN  NNNN       NNNNN
NNNN        NNNN  NNNNNNN     NNNN  NNNN        NNNN  NNNN        NNNN  NNNN        NNNN
NNNN        NNNN  NNNNNNNN    NNNN  NNNN        NNNN  NNNN        NNNN  NNNN        NNNN
NNNN        NNNN  NNNN NNNN   NNNN  NNNN        NNNN  NNNN        NNNN  NNNN        NNNN
NNNN        NNNN  NNNN  NNNN  NNNN  NNNN        NNNN  NNNN       NNNNN  NNNN       NNNNN
NNNNNNNNNNNNNNNN  NNNN   NNNN NNNN  NNNN        NNNN  NNNNNNNNNNNNNNNN  NNNNNNNNNNNNNNNN
NNNNNNNNNNNNNNNN  NNNN    NNNNNNNN  NNNN        NNNN  NNNNNNNNNNNNNNN   NNNNNNNNNNNNNNN
NNNNNNNNNNNNNNNN  NNNN     NNNNNNN  NNNN        NNNN  NNNNNNNNNNNNNN    NNNNNNNNNNNNNN
NNNN        NNNN  NNNN      NNNNNN  NNNNN      NNNNN  NNNN              NNNN
NNNN        NNNN  NNNN       NNNNN  NNNNNNNNNNNNNNNN  NNNN              NNNN
NNNN        NNNN  NNNN        NNNN   NNNNNNNNNNNNNN   NNNN              NNNN
NNNN        NNNN  NNNN        NNNN    NNNNNNNNNNNN    NNNN              NNNN
```

```
1                                  6/29/99            ANOPP LEVEL 03/02/11                    PAGE      1

                                                         ANOPP INITIALIZATION PHASE

                                   ANOPP JECHO=.FALSE. JLOG=.FALSE. NLPPM=60 $
                                   STARTCS $

                                                          ANOPP EXECUTIVE PARAMETERS
                                                          --------------------------

           NOGO = F                JECHO = F                                 JLOG = F

                                     MAXIMUM TABLE DIRECTORY ENTRIES                 =      10

                                     MAXIMUM UNIT DIRECTORY ENTRIES                  =      25

                                     CHECKPOINT FILE (IF REQUESTED)                  = CPFILE

                                     NUMBER OF LINES PER PAGE                        =      60

                                     MAXIMUM NUMBER OF CARDS IN PRIMARY INPUT STREAM =   10000

                                     MAXIMUM LENGTH OF GLOBAL DYNAMIC STORAGE        =   12000


****************** DBM INFORMATIVE MESSAGE   76 *** XUPNEW - UNIT SFIELD   IS BEING CREATED DYNAMICALLY.******************
 APPLICABLE DIAGNOSTIC MESSAGES PRECEDE CARD IMAGE

                                                               HEADER SECTION

 UPDATE PROCESSING BEGINNING WITH THE FOLLOWING PARAMETERS
 CREATE   MODE                    NEW DATA UNIT = SFIELD                        OLD DATA UNIT = NONE
 SOURCE OF UPDATE DIRECTIVES IS PRIMARY INPUT STREAM                            LIST = NONE

****************** DBM INFORMATIVE MESSAGE   76 *** XUPNEW - UNIT ATM      IS BEING CREATED DYNAMICALLY.******************
 APPLICABLE DIAGNOSTIC MESSAGES PRECEDE CARD IMAGE


HEADER SECTION

 UPDATE PROCESSING BEGINNING WITH THE FOLLOWING PARAMETERS
 CREATE   MODE                    NEW DATA UNIT = ATM                           OLD DATA UNIT = NONE
 SOURCE OF UPDATE DIRECTIVES IS PRIMARY INPUT STREAM                            LIST = NONE

****************** DBM INFORMATIVE MESSAGE   76 *** XUPNEW - UNIT OBSERV   IS BEING CREATED DYNAMICALLY.******************
```

```
 APPLICABLE DIAGNOSTIC MESSAGES PRECEDE CARD IMAGE

                                                                 HEADER SECTION

 UPDATE PROCESSING BEGINNING WITH THE FOLLOWING PARAMETERS
 CREATE   MODE                     NEW DATA UNIT = OBSERV                      OLD DATA UNIT = NONE
 SOURCE OF UPDATE DIRECTIVES IS PRIMARY INPUT STREAM                           LIST = NONE
1                                  6/29/99           ANOPP LEVEL 03/02/11                    PAGE      2


                                                                 FAN NOISE MODULE


                                                                 INPUT PARAMETERS

      AE     =    .10000000E+01       RS      =   .10000000E+03       AFAN   =    .47336104E+01       DIAM   =    .24550000E+01
      MD     =    .14460000E+01       RSS    =    .17000000E+01       MDOT   =    .10897276E+01       MA     =    .20860000E+00
      N      =    .25160670E+00       DELTAT =    .77912184E-01       CA     =    .11354235E+04       RHOA   =    .22976323E-02
      NBANDS =      0                 METHOD =      1                 NENG   =      2                 NB     =     30
      NV     =     61
      IGV    =      1                 DIS    =      1                 IOUT   =      1                 IPRINT =      3
      INRS   =      T                 INCT   =      F                 INDIS  =      T                 IDBB   =      F
      IDRS   =      F                 INBB   =      T                 SCRNNN =      1                 SCRXXX =    XXX
      IUNITS =    ENGLISH             STIME   =   .00000000E+00

                                                                 UNIT MEMBERS

                                     SFIELD  (FREQ    ) IS ALTERNATE NAME OF SFIELD  (FREQ    )
                                     FANIN   (XXX001  ) IS ALTERNATE NAME OF HDNFAN  (XXX001  )
                                     SFIELD  (PHI     ) IS ALTERNATE NAME OF SFIELD  (PHI     )
                                     SFIELD  (THETA   ) IS ALTERNATE NAME OF SFIELD  (THETA   )


1                                  6/29/99           ANOPP LEVEL 03/02/11                    PAGE      4


                                                                 FAN NOISE MODULE


                                                                 INPUT PARAMETERS

      AE     =    .10000000E+01       RS      =   .10000000E+03       AFAN   =    .47336104E+01       DIAM   =    .24550000E+01
      MD     =    .14460000E+01       RSS    =    .17000000E+01       MDOT   =    .10897276E+01       MA     =    .20860000E+00
      N      =    .25160670E+00       DELTAT =    .77912184E-01       CA     =    .11354235E+04       RHOA   =    .22976323E-02
      NBANDS =      0                 METHOD =      1                 NENG   =      2                 NB     =     30
      NV     =     61
      IGV    =      1                 DIS    =      1                 IOUT   =      1                 IPRINT =      3
      INRS   =      F                 INCT   =      F                 INDIS  =      F                 IDBB   =      T
```

```
       IDRS   =      T                INBB   =     F                SCRNNN =      1               SCRXXX =    XXX
       IUNITS =    ENGLISH            STIME   =   .00000000E+00

                                                UNIT MEMBERS

                                      SFIELD  (FREQ    ) IS ALTERNATE NAME OF SFIELD  (FREQ    )
                                      FANOUT  (XXX001  ) IS ALTERNATE NAME OF HDNFAN  (XXX001  )
                                      SFIELD  (PHI     ) IS ALTERNATE NAME OF SFIELD  (PHI     )
                                      SFIELD  (THETA   ) IS ALTERNATE NAME OF SFIELD  (THETA   )
1                                    6/29/99             ANOPP LEVEL 03/02/11                    PAGE      6

                                             COMBUSTION NOISE MODULE

                                    MODULE GECOR USES THE FOLLOWING INPUT PARAMETERS AND UNIT MEMBERS

      AE     =  1.0000         A      =  .47336         RS     =  316.23         STIME  =  .00000E+00      MDOT   =  .17051
      MA     =  .20860         TI     =  1.8687         TCJ    =  3.8662         CA     =  1135.4         RHOA   =  .22976E-02
      PI     =  6.4914         TDDELT =  1.0000         IOUT   =  1              NENG   =  2              IPRINT =  3
      SCRNNN =  1              SCRXXX = XXX             ICAO78 =  F              METHOD =  1              IUNITS = ENG

                                      SFIELD  (FREQ    ) IS ALTERNATE NAME OF SFIELD  (FREQ    )
                                      GECOR   (XXX001  ) IS ALTERNATE NAME OF GECOR   (XXX001  )
                                      SFIELD  (PHI     ) IS ALTERNATE NAME OF SFIELD  (PHI     )
                                      SFIELD  (THETA   ) IS ALTERNATE NAME OF SFIELD  (THETA   )
1                                    6/29/99             ANOPP LEVEL 03/02/11                    PAGE      8

                                          SINGLE  STREAM  CIRCULAR  JET  NOISE  MODULE

                                    MODULE SGLJET USES THE FOLLOWING INPUT PARAMETERS AND UNIT MEMBERS

      AJ     =  2.6901         RHOJ   =  .74427         TJ     =  1.4055         VJ     =  .60982         RS     =  100.00
      RHOA   =  .22976E-02     IUNITS =    ENGLISH      CA     =  1135.4         MA     =  .20860         AE     =  1.0000
      DELTA  =  .00000E+00     NENG   =   2             SCRXXX = XXX             SCRNNN =  1              IOUT   =  1
      IPRINT =  3              STIME  =  .00000E+00     SHOCK  =  F              METHOD =  1

                                      SFIELD  (FREQ    ) IS ALTERNATE NAME OF SFIELD  (FREQ    )
                                      SFIELD  (PHI     ) IS ALTERNATE NAME OF SFIELD  (PHI     )
                                      SFIELD  (THETA   ) IS ALTERNATE NAME OF SFIELD  (THETA   )
                                      SAE     (MTH     ) IS ALTERNATE NAME OF SAE     (MTH     )
                                      SAE     (OM      ) IS ALTERNATE NAME OF SAE     (OM      )
                                      SAE     (PDF     ) IS ALTERNATE NAME OF SAE     (PDF     )
                                      SAE     (NDF     ) IS ALTERNATE NAME OF SAE     (NDF     )
```

```
                                   SAE     (SJC      ) IS ALTERNATE NAME OF SAE     (SJC      )
                                   SAE     (SCF      ) IS ALTERNATE NAME OF SAE     (SCF      )
                                   SGLJET  (XXX001   ) IS ALTERNATE NAME OF SGLJET  (XXX001   )
1                                 6/29/99             ANOPP LEVEL 03/02/11                    PAGE     10


                                        ATMOSPHERIC MODEL FOR AIRCRAFT NOISE PREDICTION


                                         PARAMETERS RETRIEVED FROM USER PARAMETER TABLE

                                   DELH  =    328.08      H1    =       .00      IUNITS = ENGLISH
                                   NHO   =         1      P1    =   2116.22      IPRINT =  3


****************** DBM INFORMATIVE MESSAGE   76 *** MMOPWD - UNIT SCRATCH  IS BEING CREATED DYNAMICALLY.******************
  ------------------------------------------------------------------------------------------------------------------------------

                                              ATMOSPHERIC PROPERTIES OUTPUT
                              TABLE TMOD     ON UNIT ATM      CONVERTED TO DIMENSIONAL UNITS
                                  ALTITUDE IS RELATIVE TO GROUND LEVEL OF      0.   FEET
  ------------------------------------------------------------------------------------------------------------------------------
 ALTITUDE   PRESSURE     DENSITY    TEMPERATURE  SOUND SPEED  AVERAGE SOUND   HUMIDITY    VISCOSITY     THERMAL  CHARACTERISTIC
                                                                   SPEED                              CONDUCTIVITY   IMPEDANCE
   FEET     LB/FT**2    SLUG/FT**3     DEG R        FT/S          FT/S     % MOLE FRACTION SLUG/(FT S) BTU(DEG R M S) SLUG(S FT**2)
  ------------------------------------------------------------------------------------------------------------------------------
       0.  .211622E+04  .229718E-02  .536670E+03  .113566E+04  .113566E+04  .218960E+01  .383694E-06  .419313E-05  .260881E+01
1                                 6/29/99             ANOPP LEVEL 03/02/11                    PAGE     11


                                                    ATMOSPHERIC ABSORPTION MODULE

                                             INPUT VALUES READ FROM USER PARAMETER TABLE
                     IUNITS = ENGLISH             ABSINT =  5                IPRINT =  3                  ISAE =  2

                                         24 FREQUENCY VALUES READ FROM UNIT MEMBER SFIELD  (FREQ     )
         50.00           63.00           80.00          100.00          125.00          160.00          200.00          250.00
        315.00          400.00          500.00          630.00          800.00         1000.00         1250.00         1600.00
       2000.00         2500.00         3150.00         4000.00         5000.00         6300.00         8000.00        10000.00

 *** ATM     (AAC     ) *** TMEDI1 - LINEAR EXTRAP ATTEMPTED ON INDEPENDENT VARIABLE 1 WILL RESULT IN CLOSEST VALUE METHOD
  ------------------------------------------------------------------------------------------------------------------------------

                                  ATMOSPHERIC ABSORPTION COEFFICIENT IN DECIBELS/WAVELENGTH
                                                    ANSI STANDARD METHOD
                                         TABLE   AAC     ON UNIT   ATM     CONVERTED.
  ------------------------------------------------------------------------------------------------------------------------------
```

```
 ALTITUDE     FREQUENCIES
   FEET          50.00       63.00       80.00      100.00      125.00      160.00      200.00      250.00      315.00      400.00
  ----------------------------------------------------------------------------------------------------------------------------------
        0.    .11775E-04  .18654E-04  .29971E-04  .46581E-04  .72187E-04  .11658E-03  .17848E-03  .27037E-03  .40899E-03  .61212E-
03

 ALTITUDE     FREQUENCIES
   FEET         500.00      630.00      800.00     1000.00     1250.00     1600.00     2000.00     2500.00     3150.00     4000.00
  ----------------------------------------------------------------------------------------------------------------------------------
        0.    .86553E-03  .11928E-02  .15877E-02  .19912E-02  .24182E-02  .29324E-02  .34813E-02  .41930E-02  .52386E-02  .68795E-
02

 ALTITUDE     FREQUENCIES
   FEET        5000.00     6300.00     8000.00    10000.00
  ----------------------------------------------------------------------------------------------------------------------------------
        0.    .92515E-02  .13077E-01  .19353E-01  .28570E-01

          SFO       USES DEFAULT VALUES FOR FOLLOWING PARAMETERS
          ------------------------------------------------------------
            NAME       TYPE     CODE    ELEMENT      VALUE
          ------------------------------------------------------------
          DELTA         RS         2     (  1)    .00000000000000E+00
          DELMACH       RS         2     (  1)    .50000000000000E-01
          TF            RS         2     (  1)    .10000000000000E+03
          TSTEP         RS         2     (  1)    .50000000000000E+00
          THROT         RS         2     (  1)    .10000000000000E+01
          XF            RS         2     (  1)    .00000000000000E+00
          YF            RS         2     (  1)    .00000000000000E+00
          YI            RS         2     (  1)    .00000000000000E+00
          ZGR           RS         2     (  1)    .00000000000000E+00

 ********************************** FUNCTIONAL MODULE ERROR   10 OCCURRED IN MODULE SFO     .************************************

 USER PARAMETER TLG      HAS VALUE   -.10000000E+01 THAT IS OUT OF RANGE - DEFAULT VALUE    .00000000E+00 WILL BE USED.

          SFO       USES DEFAULT VALUES FOR FOLLOWING PARAMETERS
          ------------------------------------------------------------
            NAME       TYPE     CODE    ELEMENT      VALUE
          ------------------------------------------------------------
          ZOPT          I          1     (  1)         1
          J             I          1     (  1)         1
          APPEND        L          6     (  1)    F
1                                6/29/99             ANOPP LEVEL 03/02/11                     PAGE     12

                                                              STEADY FLYOVER MODULE

                                          MODULE SFO USES THE FOLLOWING INPUT PARAMETERS AND UNIT MEMBERS
```

```
TI     =      1.87    TF     =     100.00    ALPHA  =       4.20    TLG    =        .00    PLG    =       DOWN
VI     =    236.85    VF     =     236.85    DELTA  =        .00    ZGR    =        .00    ENGNAM =        XXX
XI     = -10685.00    XF     =        .00    THW    =       3.00    TSTEP  =        .50    IUNITS =    ENGLISH
YI     =       .00    YF     =        .00    THROT  =       1.00    IPRINT =          1    APPEND =          F
ZI     =    559.21    ZF     =        .00    DELMACH=        .05    ZOPT   =          1    J      =          1

                                  ATM     (TMOD    ) IS ALTERNATE NAME OF ATM     (TMOD    )
                                  FLI     (PATH    ) IS ALTERNATE NAME OF FLI     (PATH    )
                                  FLI     (FLIXXX  ) IS ALTERNATE NAME OF FLI     (FLIXXX  )


***************** DBM INFORMATIVE MESSAGE   76 *** MMOPWD - UNIT FLI      IS BEING CREATED DYNAMICALLY.*****************

 **************************************************** STEADY FLYOVER MODULE ****************************************************
                                          NORMAL TERMINATION - FINAL CONDITIONS REACHED

      GEO       USES DEFAULT VALUES FOR FOLLOWING PARAMETERS
      -------------------------------------------------------------
        NAME       TYPE     CODE    ELEMENT      VALUE
      -------------------------------------------------------------
      DIRECT        L          6     (  1)    F
      GEOERR        L          6     (  1)    F

      GEO       USES DEFAULT VALUES FOR FOLLOWING PARAMETERS
      -------------------------------------------------------------
        NAME       TYPE     CODE    ELEMENT      VALUE
      -------------------------------------------------------------
      AW            RS         2     (  1)    .32808000000000E+01
      CTK           RS         2     (  1)    .10000000000000E+01
      DELDB         RS         2     (  1)    .20000000000000E+02
      MASSAC        RS         2     (  1)    .28559900000000E+02
      DTIME         RS         2     (  1)    .50000000000000E+00
      DELTH         RS         2     (  1)    .10000000000000E+02
1                                  6/29/99            ANOPP LEVEL 03/02/11                     PAGE     13


                                                   SOURCE TO OBSERVER GEOMETRY


                                                    GEO USER PARAMETER INPUT

     AW     =  3.2808     FT**2      CTK    =  1.0000     SEC        DELB   =  20.000     DB         MASSAC =  28.560     SLUGS
     START  =  .00000E+00 SEC        STOP   =  80.000     SEC        DTIME  =  .50000     SEC        DELTH  =  10.000     DEGREES
     ICOORD =  1                     IPRINT =  1                     IUNITS = ENGLISH                DIRECT =  F
```

```
****************** DBM INFORMATIVE MESSAGE   76 *** MMOPWS - UNIT GEO      IS BEING CREATED DYNAMICALLY.******************
1                                  6/29/99            ANOPP LEVEL 03/02/11                     PAGE     15

                                                           SOURCE TO OBSERVER GEOMETRY


                                                       SOURCE COORDINATE SYSTEM DESCRIPTION

               INDEX   NAME                            ORIGIN OFFSET                                   EULER ANGLES
                                                          (FEET)                                         (DEGREES)
                                            X             Y            Z           PSI           THETA           PHI
                 1     BODY                   .00           .00          .00         .00            .00            .00


                                                              OBSERVER COORDINATES

                                                     NO.         X            Y            Z
                                                      1     -7516.00          .00         4.00

****************** DBM INFORMATIVE MESSAGE   76 *** XUPNEW - UNIT FLIMOD   IS BEING CREATED DYNAMICALLY.******************
 APPLICABLE DIAGNOSTIC MESSAGES PRECEDE CARD IMAGE

                                                                HEADER SECTION

 UPDATE PROCESSING BEGINNING WITH THE FOLLOWING PARAMETERS
 REVISE   MODE                    NEW DATA UNIT = FLIMOD                      OLD DATA UNIT = FLI
 SOURCE OF UPDATE DIRECTIVES IS PRIMARY INPUT STREAM                          LIST = NONE

          PRO       USES DEFAULT VALUES FOR FOLLOWING PARAMETERS
          ------------------------------------------------------------
            NAME       TYPE     CODE    ELEMENT      VALUE
          ------------------------------------------------------------
          NBAND         I          1     (  1)          5
          STATIC        L          6     (  1)    F
          SIDELN        L          6     (  1)    T

          PRO       USES DEFAULT VALUES FOR FOLLOWING PARAMETERS
          ------------------------------------------------------------
            NAME       TYPE     CODE    ELEMENT      VALUE
          ------------------------------------------------------------
          COH           RS         2     (  1)    .10000000000000E-01
          SIGMA         RS         2     (  1)    .48508000000000E+03
          RO            RS         2     (  1)    .65616800000000E+01
          ZS            RS         2     (  1)    .32808400000000E+01
```

```
       ZO             RS          2     (  1)    .32808400000000E+01
       PROTIME        A          -3     (  1)  XXX
       SURFACE        A          -4     (  1)  SOFT
1                                6/29/99             ANOPP LEVEL 03/02/11                     PAGE     16


                                                      PROPAGATION MODULE

                                          MODULE PRO USES THE FOLLOWING INPUT PARAMETERS AND UNIT MEMBERS

     SIGMA   =  485.08          RS      =  100.00          RO      =  6.5617          ZS      =  3.2808          ZO      =  3.2808
     COH     =  .10000E-01      IPRINT  =  1               IOUT    =  1               NBAND   =  5               PROTIME = XXX
     SURFACE = SOFT             GROUND  =  T               ABSORP  =  T               STATION =  F               SIDELINE=  T
     IUNITS  = ENGLISH

 ********** FOR MOVING NOISE SOURCE, PARAMETERS RS, RO, ZS, ZO, AND SIDELINE ARE IGNORED **********

                                    ATM     (AAC     ) IS ALTERNATE NAME OF ATM     (AAC     )
                                    ATM     (TMOD    ) IS ALTERNATE NAME OF ATM     (TMOD    )
                                    GEO     (BODY    ) IS ALTERNATE NAME OF GEO     (GEOM    )
                                    FLIMOD  (FLIXXX  ) IS ALTERNATE NAME OF FLI     (FLIXXX  )
                                    PRO     (PRES    ) IS ALTERNATE NAME OF PRO     (PRES    )
                                    SCRATCH (XXXNNN  ) IS ALTERNATE NAME OF SCRATCH (XXXNNN  )
 THE FOLLOWING NOISE UNITS WILL BE USED
   FANIN

****************** DBM INFORMATIVE MESSAGE   76 *** MMOPWD - UNIT PRO      IS BEING CREATED DYNAMICALLY.******************

          WING      USES DEFAULT VALUES FOR FOLLOWING PARAMETERS
          ------------------------------------------------------------
            NAME       TYPE     CODE    ELEMENT      VALUE
          ------------------------------------------------------------
          METHOD        I          1     (  1)         1
1                                6/29/99             ANOPP LEVEL 03/02/11                     PAGE     17


                                                WING GEOMETRIC EFFECTS MODULE

                                          MODULE WING USES THE FOLLOWING INPUT PARAMETERS AND UNIT MEMBERS

     IPRINT  =  3                  METHOD  =  1              IUNITS  = ENGLISH

     ROOTLE  =  10.40000     2.20000    -1.60000
     ROOTTE  =    -.30000     2.20000    -1.60000
     TIPLE   =     .80000     1.10000    20.80000
     TIPTE   =  -2.60000     1.10000    20.80000

                                    GEO     (BODY    ) IS ALTERNATE NAME OF GEO     (BODY    )
```

```
                                 PRO      (PRES     ) IS ALTERNATE NAME OF PRO      (PRES     )
                                 SFIELD   (FREQ     ) IS ALTERNATE NAME OF SFIELD   (FREQ     )
                                 WING     (PRES     ) IS ALTERNATE NAME OF WING     (PRES     )

****************** DBM INFORMATIVE MESSAGE   76 *** MMOPWD - UNIT WING     IS BEING CREATED DYNAMICALLY.******************
1                                 6/29/99            ANOPP LEVEL 03/02/11                    PAGE     18

                                                  WING GEOMETRIC EFFECTS MODULE

                      OBSERVER    1 LOCATED AT X=  -7516.0000         Y=   .00000000E+00     Z=   4.0000000

 FREQUENCIES      .50000E+02     .63000E+02     .80000E+02     .10000E+03     .12500E+03     .16000E+03     .20000E+03     .25000E+03
                  .31500E+03     .40000E+03     .50000E+03     .63000E+03     .80000E+03     .10000E+04     .12500E+04     .16000E+04
                  .20000E+04     .25000E+04     .31500E+04     .40000E+04     .50000E+04     .63000E+04     .80000E+04     .10000E+05


 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
     5.20 ATTN           .00            .00            .00            .00            .00            .00            .00            .00
          ATTN           .00            .00            .00            .00            .00            .00            .00            .00
          ATTN           .00            .00            .00            .00            .00            .00            .00            .00

 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
     5.70 ATTN           .00            .00            .00            .00            .00            .00            .00            .00
          ATTN           .00            .00            .00            .00            .00            .00            .00            .00
          ATTN           .00            .00            .00            .00            .00            .00            .00            .00

 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
     6.20 ATTN           .00            .00            .00            .00            .00            .00            .00            .00
          ATTN           .00            .00            .00            .00            .00            .00            .00            .00
          ATTN           .00            .00            .00            .00            .00            .00            .00            .00

 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
     6.70 ATTN          2.73           3.02           3.31           3.56           3.79           4.01           4.19           4.34
          ATTN          4.47           4.58           4.66           4.74           4.80           4.85           4.89           4.92
          ATTN          4.95           4.97           4.98           5.01           5.03           5.06           5.11           5.16

 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
     7.20 ATTN          2.71           3.00           3.29           3.55           3.78           4.01           4.19           4.35
          ATTN          4.49           4.61           4.71           4.79           4.87           4.95           5.01           5.08
          ATTN          5.15           5.22           5.30           5.40           5.52           5.67           5.86           6.08

 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
     7.70 ATTN          2.70           2.99           3.28           3.54           3.78           4.02           4.21           4.38
          ATTN          4.53           4.67           4.79           4.91           5.02           5.13           5.25           5.38
          ATTN          5.52           5.68           5.86           6.09           6.36           6.68           7.08           7.51

 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
```

```
    8.20 ATTN           2.68          2.98          3.27          3.54          3.79          4.04          4.25          4.43
         ATTN           4.61          4.77          4.92          5.08          5.24          5.41          5.59          5.82
         ATTN           6.05          6.33          6.64          7.03          7.46          7.96          8.55          9.17

OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    8.70 ATTN           2.67          2.97          3.27          3.55          3.81          4.08          4.30          4.51
         ATTN           4.72          4.92          5.11          5.32          5.55          5.79          6.06          6.40
         ATTN           6.74          7.15          7.61          8.15          8.72          9.38         10.12         10.85
1                                  6/29/99            ANOPP LEVEL 03/02/11                 PAGE      19


                                                 WING GEOMETRIC EFFECTS MODULE


OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    9.20 ATTN           2.66          2.96          3.28          3.56          3.84          4.13          4.38          4.62
         ATTN           4.86          5.12          5.36          5.64          5.95          6.28          6.65          7.11
         ATTN           7.57          8.10          8.70          9.38         10.06         10.82         11.64         12.42

OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    9.70 ATTN           2.65          2.96          3.29          3.59          3.89          4.20          4.49          4.76
         ATTN           5.06          5.37          5.68          6.03          6.44          6.87          7.34          7.93
         ATTN           8.51          9.16          9.87         10.64         11.40         12.21         13.06         13.84

OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   10.20 ATTN           2.65          2.97          3.31          3.63          3.95          4.30          4.62          4.95
         ATTN           5.30          5.68          6.07          6.51          7.02          7.55          8.14          8.85
         ATTN           9.53         10.27         11.08         11.90         12.69         13.51         14.34         15.09

OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   10.70 ATTN           2.66          2.99          3.34          3.68          4.03          4.43          4.80          5.18
         ATTN           5.60          6.06          6.54          7.07          7.69          8.32          9.01          9.82
         ATTN          10.59         11.40         12.26         13.11         13.90         14.69         15.48         16.19

OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   11.20 ATTN           2.67          3.01          3.39          3.76          4.14          4.59          5.01          5.46
         ATTN           5.96          6.51          7.08          7.72          8.44          9.16          9.94         10.84
         ATTN          11.66         12.51         13.40         14.27         15.02         15.77         16.51         17.14

OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   11.70 ATTN           2.69          3.05          3.45          3.86          4.28          4.79          5.28          5.80
         ATTN           6.38          7.04          7.70          8.43          9.25         10.06         10.91         11.87
         ATTN          12.73         13.59         14.49         15.36         16.07         16.76         17.42         17.98

OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   12.20 ATTN           2.73          3.11          3.54          3.98          4.46          5.03          5.59          6.20
         ATTN           6.87          7.63          8.38          9.20         10.10         10.98         11.89         12.88
         ATTN          13.75         14.62         15.50         16.39         17.05         17.66         18.24         18.72
```

```
 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   12.70 ATTN        2.78        3.19        3.66        4.15        4.68        5.32        5.96        6.65
         ATTN        7.41        8.26        9.09        9.99       10.95       11.88       12.82       13.82
         ATTN       14.69       15.55       16.41       17.26       17.95       18.48       18.97       19.37

 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   13.20 ATTN        2.87        3.30        3.81        4.34        4.93        5.64        6.35        7.11
         ATTN        7.94        8.86        9.75       10.70       11.70       12.65       13.61       14.61
         ATTN       15.47       16.30       17.14       17.96       18.70       19.20       19.60       19.73
1                               6/29/99          ANOPP LEVEL 03/02/11                  PAGE     20


                                                 WING GEOMETRIC EFFECTS MODULE


 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   13.70 ATTN        2.98        3.44        3.98        4.55        5.17        5.93        6.67        7.47
         ATTN        8.35        9.29       10.21       11.17       12.19       13.15       14.12       15.11
         ATTN       15.95       16.77       17.59       18.39       19.11       19.72       19.73       19.73

 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   14.20 ATTN        3.12        3.60        4.15        4.72        5.35        6.10        6.84        7.63
         ATTN        8.49        9.42       10.32       11.28       12.29       13.25       14.21       15.20
         ATTN       16.04       16.85       17.67       18.45       18.91       19.33       19.71       19.73

 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   14.45 ATTN        3.20        3.68        4.22        4.78        5.39        6.11        6.82        7.58
         ATTN        8.41        9.31       10.19       11.13       12.13       13.07       14.03       15.02
         ATTN       15.86       16.68       17.50       18.10       18.59       19.05       19.47       19.73

 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   14.70 ATTN        3.28        3.75        4.27        4.80        5.38        6.06        6.72        7.43
         ATTN        8.21        9.07        9.91       10.82       11.80       12.73       13.67       14.67
         ATTN       15.52       16.35       17.02       17.65       18.20       18.70       19.16       19.54

 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   14.95 ATTN        3.35        3.80        4.30        4.80        5.32        5.95        6.56        7.21
         ATTN        7.93        8.73        9.53       10.40       11.34       12.24       13.17       14.17
         ATTN       15.02       15.75       16.46       17.14       17.73       18.28       18.79       19.21

 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   15.20 ATTN        3.43        3.86        4.32        4.78        5.27        5.83        6.39        6.98
         ATTN        7.65        8.39        9.14        9.96       10.87       11.75       12.66       13.64
         ATTN       14.42       15.17       15.91       16.64       17.26       17.86       18.42       18.88

 OBS. TIME                                  WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   15.45 ATTN        3.50        3.92        4.36        4.80        5.25        5.78        6.30        6.86
```

```
         ATTN         7.49          8.20          8.92          9.71         10.59         11.45         12.35         13.28
         ATTN        14.06         14.82         15.58         16.33         16.98         17.60         18.18         18.67

OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   15.70 ATTN         3.58          3.99          4.43          4.86          5.32          5.85          6.37          6.93
         ATTN         7.56          8.27          8.99          9.79         10.67         11.54         12.39         13.34
         ATTN        14.12         14.89         15.64         16.38         17.03         17.64         18.22         18.71

OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   15.95 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
         ATTN          .00           .00           .00           .00           .00           .00           .00           .00
         ATTN          .00           .00           .00           .00           .00           .00           .00           .00
1                            6/29/99           ANOPP LEVEL 03/02/11                      PAGE     21

                                          WING GEOMETRIC EFFECTS MODULE

OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   16.20 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
         ATTN          .00           .00           .00           .00           .00           .00           .00           .00
         ATTN          .00           .00           .00           .00           .00           .00           .00           .00

OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   16.45 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
         ATTN          .00           .00           .00           .00           .00           .00           .00           .00
         ATTN          .00           .00           .00           .00           .00           .00           .00           .00

OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   16.70 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
         ATTN          .00           .00           .00           .00           .00           .00           .00           .00
         ATTN          .00           .00           .00           .00           .00           .00           .00           .00

OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   16.95 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
         ATTN          .00           .00           .00           .00           .00           .00           .00           .00
         ATTN          .00           .00           .00           .00           .00           .00           .00           .00

OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   17.20 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
         ATTN          .00           .00           .00           .00           .00           .00           .00           .00
         ATTN          .00           .00           .00           .00           .00           .00           .00           .00

OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
   17.70 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
         ATTN          .00           .00           .00           .00           .00           .00           .00           .00
         ATTN          .00           .00           .00           .00           .00           .00           .00           .00
```

```
 OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    18.20 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    18.70 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    19.20 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
1                                 6/29/99           ANOPP LEVEL 03/02/11                    PAGE      22


                                                   WING GEOMETRIC EFFECTS MODULE


 OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    19.70 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    20.20 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    20.70 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    21.20 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    21.70 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                                   WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    22.20 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
```

```
         ATTN         .00         .00         .00         .00         .00         .00         .00         .00

 OBS. TIME                         WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    22.70 ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00

 OBS. TIME                         WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    23.20 ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00

 OBS. TIME                         WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    23.70 ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00
1                               6/29/99          ANOPP LEVEL 03/02/11              PAGE     23


                                            WING GEOMETRIC EFFECTS MODULE


 OBS. TIME                         WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    24.20 ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00

 OBS. TIME                         WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    24.70 ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00

 OBS. TIME                         WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    25.20 ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00

 OBS. TIME                         WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    25.70 ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00

 OBS. TIME                         WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    26.20 ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00
          ATTN        .00         .00         .00         .00         .00         .00         .00         .00

 OBS. TIME                         WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
```

```
    26.70 ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    27.20 ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    27.70 ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    28.20 ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00
1                                  6/29/99            ANOPP LEVEL 03/02/11                    PAGE     24


                                                WING GEOMETRIC EFFECTS MODULE


 OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    28.70 ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    29.20 ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    29.70 ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    30.20 ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                               WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    30.70 ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00
          ATTN         .00           .00           .00           .00           .00           .00           .00           .00
```

```
 OBS. TIME                                       WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    31.20 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                                       WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    31.70 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                                       WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    32.20 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                                       WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    32.70 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
1                                 6/29/99             ANOPP LEVEL 03/02/11                    PAGE     25


                                                       WING GEOMETRIC EFFECTS MODULE


 OBS. TIME                                       WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    33.20 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                                       WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    33.70 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                                       WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    34.20 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00

 OBS. TIME                                       WING GEOMETRY SPL CORRECTION FOR EACH FREQUENCY
    34.70 ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00
          ATTN          .00           .00           .00           .00           .00           .00           .00           .00

 ENTERING ANOPP NORMAL TERMINATION PHASE
 ANOPP IS TERMINATING NORMALLY
```

APPENDIX VII

TABLES OF RECEIVED SPECTRA AND PNLT FOR THE 1992 BASELINE TECHNOLOGY BUSINESS JET

(11 Pages)

File: SPECTRA.TXT - Business Jet Component Spectra at 4' Microphone for FAA Certification Conditions

Approach

30.8 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	17.2	0.0	32.9	30.8	56.6	63.1	64.0
18	20.9	0.0	35.6	31.0	57.1	63.4	64.3
19	24.0	2.5	38.3	30.7	56.8	63.3	64.2
20	26.2	4.5	40.1	29.5	55.5	62.4	63.3
21	27.1	5.4	40.4	27.6	53.3	60.7	61.5
22	31.1	9.4	43.6	28.9	54.2	62.3	62.9
23	39.3	17.6	50.9	34.4	58.9	68.0	68.6
24	45.3	23.6	56.0	38.2	61.9	71.7	72.3
25	48.0	26.4	57.7	38.9	61.5	72.3	72.8
26	45.1	23.6	53.4	34.2	55.7	66.5	67.1
27	51.8	30.4	58.3	39.3	59.3	70.1	70.8
28	53.5	32.2	56.5	39.7	58.1	69.0	69.7
29	55.2	34.0	54.5	40.3	57.0	68.0	68.7
30	56.2	35.2	51.6	40.5	55.4	66.4	67.2
31	57.4	36.6	48.8	40.7	54.2	65.3	66.3
32	58.0	37.4	45.1	41.0	52.3	63.7	65.0
33	58.2	37.9	41.2	41.8	50.3	61.8	63.7
34	58.0	38.1	36.9	43.1	48.3	60.1	62.4
35	57.5	38.0	31.6	44.5	45.9	58.0	61.0
36	58.0	40.4	25.9	44.7	43.0	53.9	59.7
37	54.7	36.1	21.4	45.6	40.8	49.8	56.5
38	52.2	34.4	15.0	44.5	37.4	44.7	53.7
39	49.1	32.7	7.0	42.5	32.7	38.3	50.4
40	42.3	25.8	0.0	38.9	26.7	30.3	44.3

40.3 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	18.5	1.8	35.1	33.0	58.4	64.8	65.7
18	21.6	4.6	37.4	32.7	58.3	64.6	65.5
19	23.7	6.6	39.1	31.4	57.1	63.5	64.4
20	24.9	7.8	40.0	29.4	55.0	61.8	62.7
21	29.1	12.2	43.8	31.0	56.2	63.6	64.4
22	37.4	20.7	51.4	36.8	61.6	69.6	70.3
23	43.6	27.1	56.9	40.5	64.5	73.5	74.1
24	46.1	29.9	58.8	41.1	64.3	74.1	74.7
25	43.0	27.2	54.9	36.3	58.5	69.1	69.6
26	50.2	34.8	61.0	42.0	63.1	73.6	74.2
27	51.4	36.4	60.5	42.0	61.6	72.1	72.8
28	53.7	39.3	59.8	43.5	61.5	72.1	72.8
29	54.1	40.3	57.0	43.3	59.5	70.4	71.0
30	55.2	42.0	54.6	44.0	58.6	69.3	69.9
31	55.8	43.4	51.7	44.2	57.3	68.1	68.8
32	55.8	44.1	47.9	44.6	55.5	66.5	67.2
33	55.8	45.0	44.4	45.8	53.8	64.9	65.8
34	55.1	45.2	40.0	47.2	51.8	63.2	64.2
35	54.4	45.6	35.0	48.8	49.7	61.3	62.6
36	54.6	47.9	29.7	49.4	47.2	57.2	60.0
37	51.0	43.9	25.4	50.4	45.2	53.3	57.1
38	48.8	42.9	19.4	49.8	42.2	48.6	54.5
39	46.0	41.8	12.3	48.7	38.4	43.1	51.9
40	40.1	36.1	4.5	46.2	33.5	36.2	48.0

47.6 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	17.4	5.3	36.3	34.0	59.2	65.3	66.2
18	19.9	7.8	38.1	33.3	58.7	64.7	65.7
19	21.2	9.3	39.2	31.3	56.8	63.0	63.9
20	23.6	11.8	41.4	30.7	56.0	62.6	63.5
21	30.9	19.4	48.3	35.5	60.5	67.6	68.4
22	38.2	27.1	55.2	40.5	65.0	72.8	73.5
23	42.5	31.8	58.9	42.5	66.3	75.0	75.7
24	41.9	31.6	57.9	40.2	63.2	72.7	73.3
25	42.8	33.1	58.2	39.6	61.6	71.8	72.4
26	49.0	40.0	63.5	44.7	65.5	75.6	76.2
27	47.4	39.1	60.4	42.1	61.5	71.6	72.3
28	50.4	42.9	60.5	44.6	62.3	72.6	73.2
29	51.5	44.8	58.6	45.4	61.4	71.7	72.3
30	52.2	46.4	55.9	45.8	60.2	70.4	71.0
31	52.8	47.9	53.2	46.2	59.1	69.4	70.0
32	52.6	48.7	49.4	46.7	57.3	67.7	68.3
33	52.4	49.4	45.8	47.9	55.6	66.1	66.8
34	51.8	49.8	41.6	49.6	53.8	64.5	65.4
35	51.4	50.6	36.6	51.2	51.8	62.5	63.6
36	51.6	52.4	31.6	51.9	49.4	58.3	60.9
37	47.8	48.7	27.3	53.0	47.5	54.6	58.3
38	46.1	48.2	21.6	52.7	44.8	50.2	56.3
39	43.6	47.1	14.8	51.8	41.3	45.0	54.3
40	38.1	42.1	7.5	49.9	36.9	38.6	51.2

57.6 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	14.9	9.9	37.6	35.0	59.9	65.3	66.4
18	16.6	11.9	38.8	33.6	58.7	64.1	65.2
19	17.7	13.3	39.9	31.7	56.8	62.4	63.5
20	23.4	19.5	45.6	34.6	59.6	65.6	66.7
21	31.0	27.5	53.0	39.9	64.7	71.2	72.1
22	36.6	33.7	58.3	43.3	67.7	74.9	75.7
23	38.3	36.0	59.7	43.1	66.7	74.8	75.5
24	35.1	33.5	56.2	38.4	61.2	70.1	70.7
25	43.2	42.4	64.0	45.4	67.1	76.5	77.2
26	42.0	42.1	62.0	43.2	63.8	73.0	73.8
27	46.6	47.5	65.0	47.1	66.2	75.5	76.3
28	46.5	48.4	62.1	46.6	64.1	73.6	74.3
29	47.4	50.3	60.1	47.3	63.1	72.6	73.3
30	47.9	51.7	57.3	47.7	61.8	71.2	71.9
31	48.5	53.2	54.6	48.2	60.9	70.2	70.9
32	48.2	54.1	50.9	48.8	59.1	68.4	69.2
33	48.2	55.0	47.4	50.4	57.6	67.0	67.9
34	47.5	55.3	43.1	52.0	55.8	65.3	66.3
35	47.8	56.6	38.2	53.7	53.9	62.9	64.7
36	47.6	57.6	33.3	54.6	51.7	58.8	62.6
37	43.7	54.4	29.1	55.6	49.9	55.2	60.4
38	42.5	54.3	23.5	55.5	47.4	51.0	59.1
39	40.0	53.0	17.1	54.9	44.2	46.1	57.7
40	35.7	48.8	10.1	53.5	40.2	40.3	55.1

File: SPECTRA.TXT - Business Jet Component Spectra at 4’ Microphone for FAA Certification Conditions

70.9 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	10.1	15.6	38.8	35.7	60.4	64.5	66.0
18	11.2	17.2	39.8	33.8	58.8	62.9	64.3
19	13.9	20.5	42.7	33.7	58.7	63.1	64.4
20	21.4	28.6	50.3	38.8	63.7	68.5	69.8
21	27.9	35.8	56.8	43.3	67.9	73.2	74.4
22	31.7	40.5	60.5	45.1	69.2	75.3	76.3
23	30.3	39.8	59.0	42.1	65.5	72.4	73.4
24	32.7	43.1	61.4	43.2	65.9	73.4	74.3
25	37.8	49.1	66.1	47.3	68.9	76.6	77.6
26	37.2	49.5	64.9	45.9	66.3	74.0	75.1
27	39.1	52.3	64.6	47.2	66.2	74.0	75.1
28	40.7	54.9	63.6	48.5	65.9	73.8	74.9
29	41.6	56.9	61.4	49.4	64.9	72.7	73.8
30	42.2	58.4	58.8	49.6	63.9	71.4	72.5
31	42.4	59.6	55.6	50.0	62.6	69.9	71.2
32	42.3	60.6	52.1	51.0	61.0	68.2	69.7
33	42.2	61.4	48.6	52.5	59.5	66.9	68.7
34	41.1	61.4	44.1	54.6	57.8	65.0	67.4
35	44.1	64.7	39.4	56.0	56.0	61.8	67.2
36	40.2	62.3	34.8	57.1	53.8	58.0	64.9
37	38.6	61.2	30.4	57.9	52.1	54.6	63.8
38	39.4	61.7	24.8	58.1	49.7	50.5	63.7
39	36.3	58.8	19.0	57.6	46.8	45.8	61.5
40	34.0	56.4	11.8	56.6	43.1	40.4	59.7

105.0 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	25.3	46.5	41.7	62.2	60.3	64.4
18	0.0	26.8	47.5	39.8	60.5	58.8	62.9
19	0.0	30.8	51.1	40.5	61.3	60.1	64.0
20	0.0	38.9	58.6	45.8	66.5	65.9	69.6
21	0.0	45.8	64.7	49.9	70.4	70.4	74.0
22	3.5	49.8	67.7	51.3	71.2	71.9	75.4
23	1.8	48.1	65.2	47.4	66.7	68.0	71.6
24	7.2	53.5	69.4	50.7	69.2	70.8	74.7
25	11.4	57.8	72.1	53.1	70.6	72.3	76.6
26	13.3	59.6	71.9	53.3	69.5	71.3	75.9
27	14.6	60.9	69.6	53.3	68.2	69.8	74.3
28	17.4	63.8	68.6	54.9	68.2	69.6	74.1
29	19.4	65.7	66.3	55.8	67.4	68.3	73.1
30	20.4	66.8	63.2	55.7	66.0	66.3	71.9
31	21.8	68.1	60.0	56.6	65.0	64.7	71.4
32	22.8	69.2	56.7	58.1	63.5	62.7	71.3
33	23.3	69.7	52.7	59.8	61.9	60.6	71.2
34	24.5	70.4	48.0	61.8	60.3	57.6	71.5
35	28.0	72.3	43.4	63.0	58.5	54.2	73.0
36	22.9	69.4	39.0	64.0	56.4	50.6	70.7
37	23.4	69.5	34.3	64.7	54.7	47.5	70.9
38	24.2	69.4	28.7	65.0	52.4	43.5	70.8
39	20.1	66.4	23.0	64.7	49.5	39.0	68.7
40	18.7	64.3	15.5	64.5	46.0	33.9	67.4

87.4 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	2.8	21.2	41.6	36.5	61.1	62.8	65.1
18	3.5	22.6	42.6	34.5	59.4	61.1	63.4
19	7.6	27.5	47.1	36.0	60.9	63.1	65.2
20	15.1	35.8	54.8	41.3	66.2	68.8	70.8
21	20.9	42.4	60.6	45.2	69.8	73.0	74.9
22	23.5	45.9	63.2	46.0	70.1	74.1	75.8
23	20.4	43.8	60.2	41.6	65.0	69.6	71.3
24	26.6	50.9	66.3	46.6	69.2	74.2	75.9
25	28.4	53.6	67.6	47.5	69.0	74.2	76.0
26	30.6	56.9	69.1	48.9	69.3	74.5	76.6
27	30.5	57.7	66.6	48.4	67.4	72.6	74.6
28	32.4	60.6	65.7	50.0	67.4	72.6	74.6
29	33.2	62.5	63.4	50.8	66.4	71.3	73.4
30	33.4	63.7	60.4	50.8	65.2	69.6	72.0
31	33.8	65.0	57.3	51.5	64.1	68.2	71.2
32	33.7	66.0	53.9	52.7	62.5	66.4	70.3
33	33.5	66.7	50.1	54.4	61.0	64.8	69.7
34	32.9	67.1	45.6	56.6	59.4	62.3	69.1
35	37.3	70.1	40.9	57.8	57.6	58.9	70.9
36	32.9	67.0	36.5	58.9	55.5	55.3	68.1
37	32.5	66.7	32.0	59.7	53.8	51.9	67.8
38	33.7	67.1	26.4	60.0	51.6	48.0	68.0
39	29.8	64.0	20.8	59.6	48.7	43.5	65.5
40	28.3	62.0	13.5	59.0	45.3	38.3	63.8

120.8 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	27.4	50.1	41.7	63.6	57.3	64.7
18	0.0	29.2	51.6	40.2	62.6	56.5	63.8
19	0.0	30.8	52.7	38.6	61.4	55.7	62.9
20	0.0	37.5	58.7	42.5	65.4	60.1	67.2
21	0.0	45.3	65.7	47.6	70.3	65.7	72.6
22	0.0	50.9	70.3	50.6	72.7	68.9	75.7
23	0.0	51.9	70.4	49.5	70.6	67.6	74.5
24	0.0	50.4	67.7	45.9	65.9	63.6	70.8
25	2.0	59.2	74.9	53.0	71.5	69.8	77.5
26	0.3	57.6	70.9	49.7	66.7	65.2	73.2
27	6.0	63.2	72.8	54.0	69.4	67.9	75.6
28	7.2	64.4	70.1	54.1	67.6	65.9	73.6
29	8.5	65.8	67.2	54.3	66.0	63.8	71.9
30	9.8	67.1	64.2	54.6	64.7	61.9	71.0
31	11.1	68.3	60.9	55.6	63.4	59.9	70.6
32	12.0	69.2	57.5	57.1	61.8	57.5	70.6
33	12.5	69.7	53.3	58.9	60.1	55.0	70.7
34	15.0	70.7	48.7	60.9	58.5	51.9	71.4
35	17.4	71.4	43.9	61.9	56.4	48.6	72.0
36	11.4	69.2	39.5	62.7	54.3	45.2	70.2
37	13.0	69.3	34.7	63.4	52.6	42.0	70.4
38	13.3	68.5	29.0	63.5	50.1	38.1	69.7
39	8.7	65.8	23.0	63.1	47.1	33.5	67.7
40	7.3	63.2	15.3	63.1	43.4	28.3	66.2

File: SPECTRA.TXT - Business Jet Component Spectra at 4' Microphone for FAA Certification Conditions

133.3 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	27.0	48.2	36.8	67.3	54.5	67.6
18	0.0	29.6	50.4	36.0	67.0	54.7	67.3
19	0.0	30.7	51.0	34.0	65.1	53.6	65.6
20	0.0	33.2	52.8	33.7	64.4	53.9	65.1
21	0.0	41.0	59.7	38.8	68.6	59.4	69.6
22	0.0	48.3	66.1	43.6	72.2	64.4	73.7
23	0.0	52.1	69.0	45.3	72.2	66.0	74.6
24	0.0	51.3	66.9	42.6	67.4	62.8	71.0
25	0.0	53.9	67.9	43.3	66.0	62.6	70.9
26	0.0	59.6	70.9	47.5	67.9	65.4	73.6
27	0.0	59.1	66.6	45.7	63.9	61.8	69.8
28	0.0	61.8	65.4	47.3	63.2	61.2	69.3
29	0.0	63.8	63.2	48.2	62.0	59.8	68.5
30	0.8	65.1	60.1	48.5	60.4	57.7	67.8
31	2.0	66.3	56.9	49.6	58.8	55.3	67.8
32	2.7	67.0	53.1	51.0	56.8	52.6	67.8
33	2.7	67.3	48.8	52.8	54.9	49.7	67.8
34	7.9	68.7	44.1	54.5	53.0	46.8	69.0
35	7.2	68.4	39.5	55.6	50.9	43.6	68.7
36	1.7	66.6	34.8	56.2	48.4	40.1	67.1
37	4.7	66.8	29.8	56.8	46.5	36.9	67.2
38	2.8	65.3	24.1	56.7	43.8	32.9	65.9
39	0.0	62.7	17.6	56.1	40.3	28.1	63.6
40	0.0	59.5	9.6	55.8	36.2	22.5	61.1

149.2 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	20.8	42.8	28.5	69.8	52.8	69.9
18	0.0	24.4	46.0	28.7	69.9	53.5	70.0
19	0.0	26.8	48.0	28.2	69.1	53.4	69.3
20	0.0	28.1	48.5	26.7	66.5	52.4	66.8
21	0.0	29.2	48.7	25.0	63.0	51.0	63.4
22	0.0	34.7	53.3	28.1	63.9	54.1	64.7
23	0.0	42.1	59.7	33.4	66.6	58.8	68.0
24	0.0	47.2	63.5	36.5	67.2	61.2	69.5
25	0.0	48.7	63.4	36.2	64.1	59.8	67.6
26	0.0	45.5	57.1	31.6	56.7	53.6	61.0
27	0.0	53.8	61.7	38.6	61.1	58.8	65.8
28	0.0	52.7	56.5	36.4	56.1	54.3	61.2
29	0.0	55.9	55.6	38.3	55.7	54.3	61.4
30	0.0	56.7	52.0	38.4	53.3	52.1	60.0
31	0.0	57.8	48.6	39.5	51.2	50.0	59.6
32	0.0	58.2	44.6	40.7	48.5	47.4	59.1
33	0.0	58.6	40.3	43.0	46.5	44.7	59.2
34	0.0	60.4	35.3	44.0	43.9	41.0	60.7
35	0.0	58.6	30.7	45.1	41.2	37.4	58.9
36	0.0	57.1	25.4	45.0	38.0	33.3	57.4
37	0.0	57.4	20.2	45.7	35.7	29.9	57.7
38	0.0	54.7	14.3	45.0	32.1	25.2	55.2
39	0.0	52.0	6.8	43.8	27.6	19.7	52.6
40	0.0	47.5	0.0	42.6	22.1	12.9	48.7

142.4 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	24.2	45.6	32.1	69.6	53.1	69.7
18	0.0	27.4	48.4	31.9	69.4	53.8	69.6
19	0.0	29.2	49.7	30.7	68.1	53.3	68.3
20	0.0	29.9	49.7	28.7	65.1	51.8	65.4
21	0.0	34.0	52.8	29.9	64.9	53.4	65.4
22	0.0	42.1	60.1	35.6	68.8	59.3	69.8
23	0.0	48.1	65.1	39.5	70.4	62.8	72.1
24	0.0	50.9	66.6	40.4	68.8	63.1	71.6
25	0.0	48.3	62.4	36.0	61.9	57.7	66.0
26	0.0	54.7	65.8	40.9	64.2	61.2	69.1
27	0.0	56.8	64.2	41.6	62.4	60.1	67.7
28	0.0	58.8	62.1	42.6	60.7	58.7	66.4
29	0.0	59.7	58.9	42.2	58.2	56.2	64.5
30	0.0	61.0	55.8	42.7	56.5	54.3	63.8
31	0.0	62.3	52.7	44.0	54.7	52.1	63.7
32	0.0	62.7	48.6	45.1	52.2	49.3	63.4
33	0.0	63.0	44.3	47.3	50.3	46.5	63.5
34	3.5	65.0	39.6	48.7	48.1	43.4	65.2
35	0.0	63.3	34.9	49.7	45.5	39.8	63.6
36	0.0	62.1	30.0	49.9	42.8	36.2	62.4
37	0.0	62.3	24.8	50.6	40.6	32.9	62.6
38	0.0	60.1	19.1	50.3	37.5	28.6	60.5
39	0.0	57.6	12.0	49.3	33.5	23.5	58.2
40	0.0	53.7	3.6	48.7	28.7	17.4	54.9

Cutback Takeoff

50.0 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	8.6	0.0	25.3	20.6	46.8	49.3	51.3
18	11.1	0.0	28.0	20.7	48.0	49.7	52.0
19	13.2	1.0	30.6	20.3	48.3	49.4	52.0
20	14.0	2.6	31.8	18.7	47.0	48.1	50.6
21	14.3	3.5	32.0	16.8	45.1	46.4	48.9
22	18.6	8.4	36.1	19.0	47.3	48.8	51.3
23	26.1	16.5	43.3	24.4	52.4	54.4	56.7
24	30.8	21.7	47.6	27.4	55.0	57.5	59.7
25	31.7	23.1	47.8	26.8	53.7	56.5	58.7
26	28.0	19.7	42.9	21.6	47.6	50.0	52.5
27	35.5	27.4	48.4	27.6	52.6	54.7	57.4
28	34.7	26.6	44.0	25.5	49.3	51.1	53.9
29	36.7	28.7	42.2	26.4	48.8	50.3	53.1
30	37.3	28.6	37.9	25.2	46.2	47.3	50.3
31	37.5	28.6	33.6	24.1	43.8	44.8	48.0
32	32.2	27.0	27.5	22.0	39.9	40.7	43.9
33	30.3	25.7	21.8	20.6	36.4	37.1	40.5
34	26.6	22.6	14.1	18.2	31.2	31.9	35.6
35	18.5	18.1	4.7	15.1	24.7	25.4	29.1
36	10.9	12.7	0.0	11.0	16.8	15.5	21.1
37	8.4	11.2	0.0	8.8	11.6	8.4	17.0
38	0.0	0.0	0.0	0.5	0.4	0.0	7.9
39	0.0	0.0	0.0	0.0	0.0	0.0	7.8
40	0.0	0.0	0.0	0.0	0.0	0.0	7.8

60.1 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	7.8	0.0	27.0	21.8	48.0	49.7	51.9
18	9.4	2.6	29.2	21.4	48.6	49.4	52.1
19	10.1	4.5	30.8	19.9	48.0	48.2	51.1
20	10.1	5.6	31.4	17.8	46.1	46.4	49.3
21	14.6	11.1	36.2	20.5	48.9	49.4	52.2
22	21.9	19.2	43.4	26.0	54.3	55.0	57.8
23	26.9	25.1	48.4	29.2	57.2	58.4	61.1
24	28.0	26.8	49.1	28.8	56.3	57.9	60.5
25	24.0	23.3	44.5	23.3	50.3	51.9	54.7
26	32.3	32.0	51.6	30.2	56.3	57.5	60.6
27	31.2	31.0	48.1	27.6	52.6	53.5	56.8
28	35.2	35.0	48.4	30.2	54.2	54.7	58.0
29	35.3	35.0	44.4	29.1	51.6	51.8	55.2
30	36.8	35.4	40.7	28.5	49.6	49.5	53.0
31	36.3	35.4	36.4	27.4	47.3	46.9	50.6
32	31.8	34.7	31.1	26.3	44.2	43.6	47.5
33	30.2	33.4	25.4	24.9	40.8	39.8	44.1
34	26.7	31.0	18.4	23.4	36.4	35.4	39.9
35	18.9	27.3	9.8	21.3	30.8	29.2	34.5
36	12.7	23.4	0.2	18.2	23.9	20.4	28.2
37	9.6	21.6	0.0	16.6	19.4	14.1	25.0
38	0.0	10.7	0.0	9.8	9.8	2.8	15.4
39	0.0	0.0	0.0	0.0	0.0	0.0	7.8
40	0.0	0.0	0.0	0.0	0.0	0.0	7.8

69.9 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	6.4	4.0	28.0	22.4	48.7	49.1	51.9
18	7.2	6.4	29.8	21.4	48.7	48.3	51.6
19	6.9	7.8	30.8	19.3	47.4	46.5	50.1
20	9.5	11.6	34.1	20.1	48.5	47.6	51.2
21	16.4	19.7	41.4	25.4	54.0	53.2	56.8
22	22.2	26.6	47.4	29.5	58.0	57.6	61.0
23	24.6	29.9	49.9	30.5	58.7	58.7	62.0
24	21.7	27.7	46.8	26.1	53.9	54.2	57.4
25	26.7	33.2	51.0	29.7	56.8	56.9	60.4
26	29.4	36.2	52.4	30.8	57.1	56.9	60.7
27	31.5	38.0	51.2	31.2	56.4	55.9	59.9
28	31.9	38.6	48.1	30.4	54.5	53.6	57.7
29	34.4	40.5	46.0	31.2	53.9	52.5	56.8
30	37.1	41.1	42.5	30.6	52.2	50.4	54.9
31	33.8	41.1	38.0	29.8	49.8	47.7	52.5
32	31.0	40.6	33.1	28.8	47.0	44.4	49.7
33	30.6	39.6	27.8	28.0	44.0	41.3	47.0
34	25.2	37.4	20.7	26.8	39.8	36.9	43.2
35	17.6	33.9	12.7	25.6	34.8	30.5	38.5
36	14.1	32.3	4.0	22.7	28.5	22.4	34.5
37	7.0	27.8	0.0	21.5	24.4	16.5	30.3
38	0.0	19.6	0.0	15.5	15.7	6.2	22.3
39	0.0	9.8	0.0	5.8	3.2	0.0	12.7
40	0.0	0.0	0.0	0.0	0.0	0.0	7.8

79.4 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	2.8	7.3	28.7	22.7	49.1	48.1	51.7
18	2.9	9.1	30.1	21.1	48.7	46.8	50.9
19	3.1	11.1	31.7	19.6	48.0	45.7	50.1
20	8.5	17.8	37.9	23.4	52.1	49.8	54.3
21	15.0	25.6	44.9	28.5	57.3	55.2	59.5
22	19.2	31.1	49.4	31.2	59.9	58.1	62.3
23	19.4	32.1	49.6	29.9	58.3	56.9	61.0
24	17.3	30.8	47.3	26.4	54.5	53.1	57.3
25	25.2	39.1	54.3	32.8	60.3	58.6	63.2
26	23.3	37.4	50.8	29.3	55.9	54.0	58.8
27	28.8	42.6	52.9	33.1	58.7	56.4	61.4
28	29.7	43.6	50.2	32.8	57.3	54.6	59.8
29	31.3	44.4	46.8	32.5	55.6	52.2	57.8
30	33.8	45.0	43.3	31.9	53.9	50.1	56.0
31	30.2	45.3	39.2	31.6	52.0	47.7	54.2
32	28.0	44.9	34.3	30.7	49.2	44.4	51.7
33	27.5	43.9	28.9	30.0	46.2	41.2	49.1
34	21.8	42.1	22.2	29.3	42.5	36.8	46.0
35	14.5	38.9	14.4	28.3	37.6	30.3	41.8
36	12.8	37.5	6.1	25.6	31.7	22.8	38.8
37	5.2	32.7	0.0	24.6	27.8	17.1	34.5
38	0.0	25.6	0.0	19.2	19.7	7.5	27.4
39	0.0	16.5	0.0	10.4	8.1	0.0	18.2
40	0.0	0.0	0.0	0.0	0.0	0.0	7.8

File: SPECTRA.TXT - Business Jet Component Spectra at 4' Microphone for FAA Certification Conditions

90.4 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	10.3	31.2	23.0	49.7	46.5	51.4
18	0.0	11.8	32.2	21.0	48.9	44.9	50.4
19	0.0	15.4	35.4	21.3	49.9	45.6	51.4
20	6.3	23.3	42.7	26.3	55.3	51.0	56.8
21	12.0	30.3	49.0	30.6	59.7	55.6	61.4
22	14.9	34.5	52.2	32.0	61.0	57.3	62.9
23	12.8	33.3	50.2	28.5	57.4	53.8	59.5
24	16.2	37.4	53.2	30.5	58.9	55.3	61.3
25	20.6	42.1	56.5	33.4	61.2	57.3	63.6
26	21.4	43.0	55.5	32.5	59.4	55.2	62.0
27	23.4	44.6	53.7	32.7	58.7	54.0	61.0
28	25.6	46.9	52.2	33.8	58.6	53.4	60.6
29	28.0	48.2	49.3	34.0	57.5	51.6	59.3
30	29.8	48.6	45.6	33.2	55.6	49.1	57.4
31	25.9	49.0	41.5	33.0	53.8	46.7	55.8
32	24.1	48.5	36.6	32.2	51.0	43.4	53.5
33	23.6	47.6	31.3	31.8	48.2	40.2	51.4
34	17.6	45.8	24.5	31.2	44.5	35.3	48.5
35	11.8	43.0	17.0	30.5	39.9	29.0	45.0
36	9.6	41.7	8.9	28.0	34.3	21.8	42.6
37	1.5	36.6	2.2	27.0	30.4	16.2	37.9
38	0.0	30.2	0.0	21.9	22.7	7.0	31.4
39	0.0	21.6	0.0	13.6	11.6	0.0	22.6
40	0.0	5.6	0.0	0.8	0.0	0.0	9.5

110.8 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	13.6	35.9	28.1	51.2	42.5	51.8
18	0.0	15.0	37.0	26.1	50.3	41.1	51.0
19	0.0	20.0	41.5	27.8	52.9	43.4	53.6
20	0.0	28.0	48.8	33.0	58.4	49.0	59.3
21	0.0	34.5	54.5	36.8	62.3	53.3	63.4
22	0.0	37.5	56.6	37.2	62.8	53.9	64.2
23	0.0	35.1	53.3	32.6	58.0	49.2	59.7
24	5.2	42.4	59.4	37.8	62.8	53.9	64.8
25	8.0	44.3	59.7	37.9	62.1	53.1	64.5
26	12.5	47.5	60.7	39.5	62.9	53.5	65.3
27	14.3	47.8	57.3	38.4	60.8	50.8	62.9
28	17.9	50.1	55.7	39.6	60.7	50.1	62.5
29	21.3	51.1	52.6	39.5	59.4	47.8	60.9
30	22.8	51.4	48.6	38.8	57.4	45.0	59.1
31	19.8	51.9	44.6	38.7	55.7	42.3	57.6
32	19.6	51.2	39.5	37.9	52.8	38.6	55.4
33	19.2	50.3	34.1	37.8	50.0	35.0	53.4
34	12.9	48.5	27.2	37.4	46.3	29.6	50.8
35	6.8	46.2	19.8	36.6	41.8	23.5	47.9
36	0.7	43.3	11.7	33.9	36.0	16.3	44.5
37	0.0	38.8	4.8	32.8	32.2	11.0	40.5
38	0.0	32.8	0.0	27.7	24.5	1.7	34.4
39	0.0	23.4	0.0	19.4	13.3	0.0	25.2
40	0.0	7.7	0.0	6.7	0.0	0.0	11.6

99.1 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	12.1	33.2	26.1	50.2	44.8	51.4
18	0.0	13.5	34.2	24.1	49.3	43.3	50.4
19	0.0	18.1	38.5	25.4	51.5	45.2	52.6
20	4.9	26.1	45.8	30.6	57.0	50.7	58.2
21	10.2	32.8	51.7	34.5	61.0	55.0	62.4
22	12.3	36.2	54.2	35.3	61.7	55.9	63.3
23	9.3	34.1	51.2	30.9	57.1	51.6	59.0
24	15.2	40.6	56.6	35.4	61.1	55.4	63.3
25	17.6	43.3	57.8	36.2	61.3	55.4	63.7
26	20.4	45.9	58.4	37.1	61.5	55.2	63.9
27	21.3	46.4	55.3	36.2	59.6	52.9	61.7
28	23.9	48.8	53.9	37.5	59.7	52.3	61.5
29	26.3	50.0	51.0	37.6	58.5	50.3	60.2
30	27.5	50.3	47.0	36.7	56.5	47.5	58.2
31	23.5	50.8	43.0	36.7	54.8	45.2	56.8
32	22.1	50.3	38.1	35.9	52.1	41.7	54.7
33	21.6	49.4	32.7	35.6	49.3	38.4	52.7
34	15.8	47.6	26.0	35.2	45.7	33.3	50.0
35	10.0	45.1	18.5	34.5	41.2	27.1	46.9
36	6.0	43.4	10.6	32.0	35.6	20.0	44.3
37	0.0	38.4	3.8	31.0	31.8	14.6	39.8
38	0.0	32.2	0.0	26.0	24.2	5.4	33.7
39	0.0	23.5	0.0	17.8	13.2	0.0	24.9
40	0.0	7.8	0.0	5.3	0.0	0.0	11.3

119.0 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	14.2	37.6	27.1	52.1	40.5	52.6
18	0.0	15.7	38.6	25.1	51.3	39.3	51.8
19	0.0	20.1	42.6	26.4	53.5	41.3	54.1
20	0.0	28.0	49.8	31.5	59.3	47.0	60.0
21	0.0	34.7	55.7	35.5	63.8	51.4	64.6
22	0.0	38.0	58.0	36.2	64.9	52.3	65.9
23	0.0	35.8	54.9	31.9	60.5	47.8	61.8
24	3.5	42.2	60.1	36.3	64.4	51.7	66.0
25	7.1	44.9	61.2	37.1	64.2	51.7	66.2
26	11.0	47.4	61.3	38.0	63.7	51.3	65.9
27	12.8	47.8	57.9	37.1	61.3	48.8	63.3
28	16.6	50.2	56.4	38.3	60.9	47.9	62.6
29	20.2	51.2	53.2	38.3	59.2	45.6	60.8
30	20.8	51.3	49.1	37.4	56.7	42.5	58.5
31	18.1	51.8	45.0	37.3	54.7	39.7	56.9
32	18.1	51.1	39.9	36.6	51.5	35.7	54.6
33	16.9	50.0	34.2	36.4	48.3	31.7	52.5
34	10.4	48.0	27.3	36.0	44.4	26.3	49.8
35	4.1	45.7	19.8	34.9	39.6	20.2	46.9
36	0.0	42.2	11.5	32.1	33.7	12.9	43.1
37	0.0	37.9	4.4	30.9	29.7	7.5	39.2
38	0.0	31.7	0.0	25.5	21.6	0.0	32.9
39	0.0	21.6	0.0	16.8	10.1	0.0	23.1
40	0.0	5.7	0.0	3.6	0.0	0.0	10.0

File: SPECTRA.TXT - Business Jet Component Spectra at 4' Microphone for FAA Certification Conditions

131.1 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	14.3	36.1	22.5	58.5	37.6	58.5
18	0.0	15.8	37.3	20.7	57.6	36.8	57.6
19	0.0	18.6	39.5	20.3	57.7	37.3	57.8
20	0.0	26.1	46.3	25.1	63.0	42.7	63.1
21	0.0	33.4	52.8	29.7	67.6	47.7	67.8
22	0.0	37.6	56.1	31.4	68.6	49.5	68.9
23	0.0	36.9	54.4	28.5	64.6	46.6	65.1
24	0.0	39.2	55.5	28.9	63.6	46.5	64.3
25	6.1	45.1	59.7	33.0	65.5	49.6	66.6
26	7.1	44.5	56.5	30.9	61.1	46.2	62.6
27	10.9	47.1	55.2	32.1	60.1	45.7	61.6
28	14.4	48.9	53.1	32.9	58.3	44.2	60.0
29	17.8	49.7	49.7	32.5	55.8	41.5	57.7
30	17.6	50.1	45.7	32.0	53.2	38.5	55.5
31	15.1	50.1	41.2	31.6	50.4	34.9	53.6
32	15.1	49.1	35.8	30.6	46.6	30.5	51.2
33	12.8	47.9	29.9	30.4	43.2	26.1	49.3
34	6.1	45.6	22.7	29.9	38.8	20.7	46.6
35	0.0	43.1	14.9	28.3	33.4	14.3	43.7
36	0.0	38.5	6.1	24.9	26.8	6.6	38.9
37	0.0	34.3	0.0	23.4	22.3	1.0	34.9
38	0.0	27.5	0.0	17.4	13.5	0.0	28.0
39	0.0	15.9	0.0	7.6	0.8	0.0	16.9
40	0.0	0.0	0.0	0.0	0.0	0.0	7.8

149.5 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	7.9	30.6	13.4	61.3	35.9	61.3
18	0.0	10.4	32.7	12.4	61.3	35.5	61.3
19	0.0	11.3	33.1	10.4	59.9	33.9	59.9
20	0.0	14.0	35.1	10.4	60.0	34.4	60.1
21	0.0	22.2	42.3	15.8	64.9	40.0	65.0
22	0.0	28.7	48.0	19.9	67.7	44.1	67.8
23	0.0	32.1	50.4	21.2	66.7	44.8	66.9
24	0.0	30.2	47.2	17.4	60.2	40.2	60.5
25	0.0	34.0	49.2	19.3	59.3	41.0	59.8
26	4.4	37.7	49.8	21.6	58.7	41.8	59.4
27	5.7	37.9	46.3	20.6	54.9	38.9	55.6
28	8.6	38.8	43.1	20.4	51.7	36.3	52.6
29	12.9	40.0	40.1	20.3	49.2	34.3	50.3
30	9.8	40.0	35.7	19.6	45.9	31.3	47.3
31	8.6	39.6	30.9	18.8	42.2	27.8	44.4
32	8.6	38.0	24.8	17.4	37.4	23.2	40.9
33	3.5	36.1	18.1	16.6	32.8	17.9	37.9
34	0.0	32.6	9.9	15.3	27.0	11.2	33.8
35	0.0	29.9	1.1	12.2	19.9	3.3	30.4
36	0.0	22.0	0.0	7.3	11.3	0.0	22.6
37	0.0	17.8	0.0	4.8	5.5	0.0	18.4
38	0.0	8.8	0.0	0.0	0.0	0.0	11.0
39	0.0	0.0	0.0	0.0	0.0	0.0	7.8
40	0.0	0.0	0.0	0.0	0.0	0.0	7.8

140.7 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	11.9	33.8	17.7	62.4	36.0	62.4
18	0.0	13.9	35.4	16.2	61.3	35.5	61.3
19	0.0	15.1	36.0	14.4	59.4	34.5	59.5
20	0.0	21.0	41.2	17.6	62.3	38.2	62.4
21	0.0	29.1	48.4	22.9	67.3	43.9	67.3
22	0.0	34.4	52.8	25.7	69.1	46.9	69.2
23	0.0	35.7	53.2	25.0	66.8	45.9	67.0
24	0.0	33.3	49.4	20.6	60.5	40.9	60.8
25	4.0	41.7	56.2	27.2	64.6	46.5	65.3
26	3.8	39.9	51.3	23.9	58.7	41.9	59.5
27	9.9	44.9	52.7	27.6	59.8	43.7	60.8
28	12.3	45.3	49.0	27.0	56.4	40.6	57.5
29	15.9	45.7	45.3	26.1	53.3	37.7	54.6
30	13.1	45.7	40.8	25.4	50.0	34.3	51.9
31	12.3	46.0	36.7	25.2	47.2	31.0	49.9
32	12.5	44.6	30.9	24.0	42.8	26.3	47.0
33	8.2	43.1	24.6	23.6	38.8	21.6	44.6
34	1.6	40.2	16.9	22.8	33.6	15.6	41.2
35	0.0	38.1	8.9	20.5	27.5	8.8	38.5
36	0.0	31.4	0.0	16.5	20.0	0.4	31.9
37	0.0	27.7	0.0	14.5	14.9	0.0	28.1
38	0.0	20.0	0.0	7.6	4.8	0.0	20.5
39	0.0	6.3	0.0	0.0	0.0	0.0	9.7
40	0.0	0.0	0.0	0.0	0.0	0.0	7.8

File: SPECTRA.TXT - Business Jet Component Spectra at 4’ Microphone for FAA Certification Conditions

Sideline

50.9 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	19.2	0.6	33.9	24.8	53.3	53.2	56.3
18	21.9	4.7	37.1	25.4	55.1	54.0	57.6
19	24.7	8.6	40.6	25.9	56.4	54.7	58.7
20	27.1	11.9	43.4	25.9	56.7	55.0	59.1
21	29.2	14.6	45.5	25.8	56.7	55.1	59.2
22	30.3	16.2	46.2	24.7	55.7	54.2	58.3
23	31.1	17.3	46.4	23.2	53.8	52.9	56.8
24	30.9	17.1	45.4	20.9	51.1	50.5	54.4
25	35.3	21.4	48.4	23.1	52.7	52.4	56.4
26	42.7	28.2	53.7	28.1	56.9	56.1	60.6
27	47.5	32.2	55.5	30.4	58.2	57.1	62.0
28	48.5	32.0	51.7	28.9	55.6	54.1	59.3
29	48.7	31.4	47.1	27.1	52.4	50.6	56.2
30	49.2	33.2	44.7	27.8	51.7	49.5	55.5
31	49.8	32.7	40.0	26.2	48.9	46.5	53.6
32	50.3	32.7	35.5	25.8	46.6	44.0	52.6
33	46.5	31.9	30.3	24.7	43.5	40.8	49.1
34	45.1	30.2	24.1	23.3	39.9	37.2	46.9
35	42.2	27.5	16.4	21.9	35.3	32.4	43.5
36	33.9	24.1	8.3	20.3	30.0	25.2	36.1
37	28.9	24.0	2.0	20.0	26.1	19.5	32.1
38	23.1	23.5	0.0	15.3	18.6	10.3	27.4
39	6.5	4.9	0.0	7.3	7.7	0.0	13.2
40	0.0	0.0	0.0	0.0	0.0	0.0	7.8

60.5 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	19.9	6.2	36.2	26.7	55.3	54.2	57.8
18	22.4	10.2	39.4	27.3	57.0	54.9	59.1
19	24.8	13.9	42.7	27.5	58.1	55.5	60.1
20	26.7	16.9	45.2	27.3	58.3	55.5	60.3
21	28.0	19.0	46.6	26.6	57.7	55.1	59.8
22	28.0	19.6	46.4	24.5	55.6	53.2	57.9
23	28.7	20.7	46.5	23.1	53.8	51.9	56.5
24	34.1	26.3	51.2	26.5	56.9	55.3	59.8
25	40.8	32.9	56.6	31.1	61.0	59.4	64.1
26	45.5	37.2	59.3	33.7	62.7	60.6	65.9
27	46.3	37.2	56.9	32.0	60.1	57.6	63.3
28	45.3	35.1	51.1	28.7	55.6	52.8	58.6
29	50.4	40.1	52.1	32.5	58.1	54.9	60.9
30	48.9	39.9	47.6	31.2	55.4	51.8	58.1
31	51.2	41.1	44.5	31.3	54.3	50.4	57.4
32	50.3	40.6	39.5	30.4	51.5	47.4	55.1
33	46.9	40.0	34.6	29.7	48.8	44.4	52.2
34	46.0	38.7	28.7	28.8	45.5	41.0	49.9
35	42.8	36.7	21.6	28.1	41.6	36.4	46.3
36	34.5	33.5	14.0	27.0	36.7	29.6	40.5
37	30.2	35.1	8.0	26.9	33.2	24.3	38.6
38	23.5	32.9	0.0	23.0	26.6	16.0	34.6
39	8.6	16.7	0.0	16.3	16.9	4.6	21.8
40	0.0	6.4	0.0	6.0	3.8	0.0	11.4

69.7 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	19.8	11.0	37.8	27.9	56.7	54.3	58.7
18	22.1	14.9	41.1	28.4	58.3	55.0	60.0
19	24.1	18.4	44.2	28.4	59.2	55.4	60.8
20	25.3	20.8	46.0	27.8	59.0	55.0	60.6
21	25.7	22.1	46.7	26.4	57.8	53.9	59.5
22	25.3	22.6	46.2	24.0	55.4	51.8	57.3
23	29.8	27.6	50.4	26.6	57.8	54.6	60.0
24	36.6	34.8	56.6	31.7	62.4	59.4	64.9
25	41.6	39.8	60.3	34.7	64.9	61.6	67.5
26	43.4	41.3	60.2	34.4	63.7	60.1	66.5
27	40.4	37.6	53.5	29.1	57.6	53.6	60.2
28	49.3	44.8	57.2	35.1	62.4	58.1	64.8
29	47.5	44.6	52.9	33.9	59.8	54.9	61.9
30	48.5	46.0	50.2	34.0	58.8	53.5	60.8
31	50.5	46.2	45.9	33.4	56.8	51.0	59.0
32	47.6	46.1	41.4	32.9	54.4	48.2	56.6
33	45.8	45.7	36.6	32.2	51.9	45.5	54.3
34	45.9	44.7	30.8	31.9	49.0	42.4	52.3
35	40.6	42.8	23.9	31.4	45.2	37.1	48.5
36	32.8	38.8	16.8	30.8	40.6	30.7	43.7
37	30.2	45.4	10.9	30.5	37.4	25.8	46.3
38	20.0	35.7	1.4	27.2	31.1	17.9	37.5
39	8.3	25.4	0.0	21.3	22.3	7.4	28.3
40	0.0	15.9	0.0	12.0	10.2	0.0	18.3

80.6 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	16.4	15.5	39.5	29.0	58.1	53.9	59.6
18	18.4	19.2	42.7	29.2	59.6	54.4	60.8
19	19.9	22.3	45.4	29.0	60.3	54.5	61.4
20	20.3	24.1	46.7	27.8	59.6	53.7	60.8
21	19.8	24.9	46.7	25.8	57.8	52.1	59.1
22	21.7	27.8	48.6	25.9	57.9	52.4	59.3
23	28.5	35.3	55.3	31.1	62.9	57.7	64.6
24	34.1	41.4	60.4	35.1	66.5	61.3	68.4
25	37.0	44.4	62.1	36.3	67.1	61.5	69.1
26	35.2	42.3	58.2	32.3	62.4	56.5	64.6
27	39.5	46.0	58.7	34.6	63.7	57.4	65.7
28	44.4	49.5	58.5	36.8	64.8	58.0	66.5
29	42.6	49.7	54.6	36.0	62.7	55.1	64.1
30	43.3	50.4	51.1	35.4	61.1	53.0	62.4
31	45.8	51.1	47.4	35.5	59.6	51.0	61.1
32	42.4	51.2	43.1	35.2	57.5	48.4	59.0
33	41.1	50.7	38.2	34.6	55.0	45.6	57.0
34	41.1	49.8	32.3	34.5	52.2	42.0	54.7
35	35.1	48.0	25.7	34.3	48.6	36.8	51.7
36	27.7	44.7	18.9	33.9	44.2	30.7	47.8
37	25.6	51.2	13.0	33.6	41.1	25.9	51.7
38	15.2	40.0	3.8	30.6	35.3	18.4	41.7
39	5.5	31.8	0.0	25.2	27.0	8.4	33.7
40	0.0	22.9	0.0	16.7	15.7	0.0	24.5

File: SPECTRA.TXT - Business Jet Component Spectra at 4’ Microphone for FAA Certification Conditions

88.6 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	14.2	18.1	41.7	29.5	59.1	53.1	60.1
18	15.9	21.7	44.8	29.6	60.5	53.5	61.4
19	17.2	24.6	47.3	29.2	61.0	53.5	61.9
20	17.2	26.0	48.2	27.7	60.0	52.4	61.0
21	16.7	26.7	48.1	25.7	58.2	50.8	59.3
22	20.7	31.8	52.2	28.0	60.5	53.3	61.8
23	27.5	39.3	58.9	33.3	65.6	58.6	67.1
24	32.4	44.6	63.2	36.5	68.5	61.4	70.3
25	34.1	46.4	63.6	36.4	67.9	60.3	69.8
26	31.1	43.0	58.4	31.2	61.9	54.0	64.0
27	39.4	50.6	62.6	37.4	67.3	58.8	69.1
28	40.4	50.4	58.5	35.9	64.6	55.7	66.1
29	40.6	52.8	56.8	37.3	64.7	55.0	66.0
30	41.3	53.2	53.0	36.4	62.9	52.5	64.1
31	43.5	53.9	49.2	36.5	61.5	50.4	62.7
32	39.7	53.7	44.7	36.0	59.0	47.4	60.5
33	39.1	53.6	40.1	35.9	57.0	45.0	59.0
34	38.8	52.5	34.1	35.8	54.1	41.0	56.7
35	32.3	50.7	27.5	35.7	50.6	35.7	53.8
36	25.2	48.1	20.9	35.4	46.3	29.8	50.5
37	22.7	54.2	14.9	35.0	43.3	25.0	54.6
38	12.8	42.2	5.9	32.2	37.6	17.7	43.8
39	3.6	35.0	0.0	27.0	29.4	7.9	36.6
40	0.0	26.3	0.0	18.7	18.4	0.0	27.6

109.2 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	22.0	46.8	35.0	61.4	49.4	61.8
18	0.0	25.4	49.8	35.0	62.6	50.0	63.1
19	0.0	27.9	51.9	34.3	63.0	49.8	63.5
20	0.0	28.8	52.2	32.4	61.8	48.4	62.4
21	0.0	30.2	52.8	31.1	60.8	47.5	61.6
22	5.6	37.4	59.0	35.6	65.5	52.3	66.6
23	12.7	44.4	65.0	40.4	70.3	56.9	71.6
24	17.6	48.6	68.1	42.6	72.3	58.6	73.9
25	18.5	48.5	66.5	40.7	69.8	55.8	71.6
26	19.5	48.0	63.8	38.5	66.8	52.5	68.7
27	28.4	55.0	67.1	44.1	71.4	56.5	73.0
28	27.5	52.7	60.9	40.7	66.7	51.1	67.9
29	30.0	56.0	60.0	42.9	67.7	51.1	68.7
30	32.5	56.7	56.4	42.5	66.2	48.7	67.1
31	34.3	57.0	52.3	42.4	64.3	46.1	65.4
32	31.9	57.2	48.1	42.3	62.2	43.2	63.6
33	32.4	56.5	42.9	41.9	59.8	39.8	61.6
34	32.2	55.6	36.9	42.2	57.0	35.4	59.5
35	25.9	53.6	30.4	42.1	53.3	30.2	56.7
36	19.7	52.5	23.6	41.4	48.9	24.2	54.3
37	15.6	55.3	17.5	41.0	45.9	19.7	55.9
38	7.0	43.7	8.3	38.1	40.0	12.2	46.0
39	0.0	37.5	0.0	32.7	31.7	2.3	39.5
40	0.0	27.8	0.0	24.2	20.5	0.0	30.0

101.1 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	21.0	45.0	33.7	60.5	51.1	61.1
18	0.0	24.4	48.0	33.7	61.8	51.6	62.3
19	0.0	27.0	50.2	33.0	62.1	51.5	62.7
20	0.0	28.1	50.6	31.2	60.9	50.1	61.6
21	0.0	29.3	51.0	29.7	59.6	48.9	60.5
22	6.3	36.1	56.9	33.8	63.8	53.3	64.9
23	13.6	43.2	63.1	38.7	68.6	58.2	70.0
24	18.6	47.7	66.5	41.2	70.8	60.0	72.4
25	19.9	48.0	65.3	39.7	68.7	57.6	70.6
26	19.9	46.6	61.9	36.5	64.8	53.4	66.8
27	29.3	54.2	65.9	42.7	70.1	58.1	71.8
28	28.8	51.8	59.7	39.2	65.5	52.7	66.8
29	31.2	55.3	59.0	41.6	66.7	53.0	67.8
30	33.5	56.0	55.4	41.1	65.3	50.7	66.3
31	35.8	56.4	51.4	41.0	63.6	48.2	64.7
32	33.3	56.5	47.0	40.8	61.4	45.3	62.9
33	33.7	56.1	42.1	40.5	59.2	42.4	61.1
34	34.0	55.1	36.2	40.7	56.4	38.1	59.0
35	28.0	53.3	29.7	40.7	52.9	32.8	56.2
36	21.9	51.6	23.0	40.2	48.6	27.0	53.6
37	18.5	56.0	16.9	39.8	45.6	22.3	56.5
38	9.6	43.8	7.9	37.0	39.9	15.0	45.9
39	0.3	37.6	0.0	31.8	31.8	5.2	39.4
40	0.0	28.5	0.0	23.6	20.7	0.0	30.3

120.3 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	22.5	48.6	33.5	64.1	46.4	64.3
18	0.0	25.9	51.6	33.5	65.5	47.2	65.7
19	0.0	28.3	53.6	32.7	65.9	47.2	66.2
20	0.0	29.3	53.8	30.9	64.7	45.9	65.1
21	0.0	30.6	54.3	29.5	63.9	45.0	64.4
22	3.5	37.4	60.2	33.8	68.6	49.5	69.3
23	10.7	44.4	66.3	38.6	73.5	54.1	74.3
24	15.7	48.7	69.4	41.0	75.4	56.0	76.4
25	16.9	48.8	67.8	39.2	72.7	53.4	74.0
26	17.4	47.7	64.3	36.5	68.4	49.4	69.9
27	26.6	54.9	67.8	42.4	72.7	53.7	74.0
28	25.2	52.5	61.4	38.8	67.3	47.9	68.4
29	27.9	55.8	60.5	41.1	67.7	47.9	68.7
30	30.5	56.4	56.8	40.6	65.6	45.3	66.6
31	31.5	56.7	52.6	40.5	63.3	42.3	64.5
32	29.3	56.6	48.1	40.2	60.7	39.0	62.3
33	30.0	55.9	42.8	39.9	57.8	35.3	60.1
34	28.8	54.8	36.7	40.1	54.7	30.8	57.9
35	22.2	52.6	30.1	40.0	50.7	25.5	54.9
36	15.8	51.9	23.0	38.9	45.9	19.4	53.1
37	11.0	52.5	16.7	38.4	42.7	14.8	53.1
38	2.6	41.9	7.2	35.1	36.4	7.1	43.6
39	0.0	35.3	0.0	29.2	27.6	0.0	36.8
40	0.0	24.5	0.0	20.1	15.6	0.0	26.3

129.6 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	22.0	46.6	29.2	69.0	43.5	69.0
18	0.0	25.5	49.7	29.2	70.7	44.6	70.7
19	0.0	28.0	51.7	28.6	70.8	44.8	70.9
20	0.0	29.1	52.1	26.9	69.4	43.7	69.5
21	0.0	30.0	52.2	25.2	67.9	42.4	68.1
22	0.7	35.8	57.0	28.4	71.1	45.8	71.3
23	8.2	43.0	63.3	33.5	75.4	50.8	75.7
24	13.7	47.8	66.8	36.3	77.0	53.2	77.4
25	15.8	48.7	66.0	35.4	74.5	51.4	75.1
26	14.4	45.7	60.4	30.8	67.7	45.5	68.5
27	24.3	53.6	64.6	37.5	72.0	50.4	72.8
28	23.1	51.7	58.7	34.5	66.6	45.1	67.4
29	25.8	54.7	57.5	36.3	66.2	44.6	67.0
30	28.2	54.9	53.4	35.7	63.4	41.5	64.4
31	28.6	55.3	49.2	35.6	60.9	38.3	62.2
32	26.3	54.7	44.2	34.9	57.5	34.3	59.5
33	27.3	54.2	39.1	34.9	54.6	30.7	57.6
34	25.0	52.6	32.5	34.7	50.8	25.9	54.9
35	18.4	50.4	25.9	34.6	46.6	20.6	52.0
36	11.5	49.8	18.4	32.9	41.3	14.3	50.5
37	6.4	48.8	11.8	32.2	37.6	9.5	49.2
38	0.0	38.5	1.9	28.4	30.7	1.3	39.5
39	0.0	31.2	0.0	21.8	21.0	0.0	32.1
40	0.0	19.1	0.0	11.7	7.7	0.0	20.2

139.4 DEGREES

BAND	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
17	0.0	19.0	43.4	23.3	72.1	40.8	72.1
18	0.0	22.6	46.7	23.5	73.3	42.0	73.3
19	0.0	25.3	48.8	23.1	73.4	42.4	73.5
20	0.0	26.6	49.4	21.7	72.2	41.5	72.2
21	0.0	27.4	49.3	19.8	70.0	40.0	70.1
22	0.0	30.8	51.9	20.8	70.8	41.1	70.9
23	4.4	38.3	58.3	26.1	75.0	46.3	75.1
24	10.7	43.8	62.5	29.7	76.8	49.3	77.0
25	14.2	46.0	63.2	30.1	75.0	48.7	75.3
26	12.4	42.6	56.7	25.1	67.5	42.4	67.8
27	20.6	48.3	58.7	29.6	69.3	45.0	69.7
28	21.2	49.6	56.0	29.9	66.7	42.8	67.2
29	22.7	50.4	52.6	29.3	63.9	40.2	64.4
30	25.4	50.4	48.1	28.6	60.6	36.8	61.3
31	24.0	50.8	44.2	28.6	57.9	33.6	58.9
32	23.0	50.1	39.1	27.8	54.2	29.7	55.8
33	23.9	49.0	33.1	27.3	50.5	25.3	52.9
34	19.5	47.3	26.5	27.1	46.3	20.4	49.9
35	13.0	43.9	19.6	26.6	41.3	14.6	45.9
36	5.7	45.6	11.3	24.0	35.1	7.7	46.0
37	0.1	39.5	4.3	23.1	30.9	2.6	40.2
38	0.0	31.6	0.0	18.5	22.9	0.0	32.3
39	0.0	22.7	0.0	10.6	11.7	0.0	23.3
40	0.0	7.9	0.0	0.0	0.0	0.0	10.5

149.4 DEGREES

17	0.0	13.3	38.7	17.1	71.1	39.3	71.1
18	0.0	17.1	42.1	17.5	71.9	40.2	71.9
19	0.0	19.9	44.4	17.4	72.6	40.5	72.6
20	0.0	21.6	45.3	16.3	71.9	40.0	71.9
21	0.0	22.8	45.6	14.8	70.3	38.7	70.3
22	0.0	23.3	45.2	12.9	67.8	36.7	67.8
23	0.0	29.5	50.5	17.0	70.4	40.3	70.5
24	6.0	36.0	55.6	21.6	72.6	44.1	72.7
25	11.1	39.9	57.8	23.6	71.8	45.0	72.0
26	12.3	39.4	54.2	21.7	66.9	41.5	67.2
27	12.7	37.3	48.4	18.3	60.7	36.3	61.0
28	18.4	43.9	50.9	23.9	63.4	39.5	63.7
29	17.7	42.3	45.1	21.0	58.0	34.7	58.3
30	21.2	43.0	41.4	21.0	55.3	32.4	55.7
31	18.8	43.0	36.9	20.5	51.9	29.2	52.6
32	17.4	41.6	31.1	19.0	47.3	24.8	48.4
33	18.2	40.3	25.0	18.6	43.3	20.2	45.2
34	12.6	37.8	17.6	17.6	38.2	14.2	41.1
35	5.4	33.7	10.0	16.4	32.3	7.5	36.2
36	0.0	35.1	0.7	12.7	24.9	0.0	35.5
37	0.0	27.1	0.0	11.3	20.0	0.0	28.0
38	0.0	18.2	0.0	5.1	10.3	0.0	19.2
39	0.0	7.1	0.0	0.0	0.0	0.0	10.1
40	0.0	0.0	0.0	0.0	0.0	0.0	7.8

File: PNLT.TXT - Business Jet Component PNLT at 4' Microphone for FAA Certification Conditions

Cutback

TIME	EMANG	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
-10.5	48.8	51.4	42.4	56.8	38.7	64.9	67.1	69.8
-10.0	50.0	51.3	44.2	57.6	39.8	65.6	67.2	70.2
-9.5	51.2	50.8	45.6	58.2	40.6	66.2	67.6	70.9
-9.0	52.5	50.7	46.9	58.7	41.4	66.7	68.0	71.4
-8.5	53.9	50.6	48.2	59.2	42.2	67.1	68.3	71.8
-8.0	55.3	50.6	49.6	59.4	42.9	67.5	68.6	72.1
-7.5	56.8	50.5	50.9	59.5	43.8	67.8	68.8	72.3
-7.0	58.4	50.3	52.2	60.2	44.4	68.5	69.3	73.0
-6.5	60.1	49.9	53.6	60.9	45.2	69.1	69.7	73.5
-6.0	61.9	49.5	54.7	61.4	46.0	69.7	69.9	73.9
-5.5	63.7	49.2	55.8	61.8	46.8	70.1	70.1	74.2
-5.0	65.7	49.0	56.8	62.1	47.6	70.5	70.1	74.3
-4.5	67.7	49.0	57.9	62.3	48.3	70.8	70.1	74.4
-4.0	69.9	49.8	59.2	62.5	49.0	71.0	69.9	74.6
-3.5	72.1	48.6	60.3	62.6	49.7	71.5	69.8	74.8
-3.0	74.5	47.6	61.5	63.0	50.3	72.0	69.9	75.3
-2.5	76.9	46.5	62.7	63.3	51.0	72.5	69.9	75.6
-2.0	79.4	45.6	64.1	63.5	51.5	72.9	69.9	75.9
-1.5	82.1	44.5	65.1	64.0	52.2	73.3	69.8	76.3
-1.0	84.8	43.3	66.1	64.7	52.6	73.7	69.6	76.7
-0.5	87.5	42.0	67.1	65.3	53.2	74.1	69.3	77.0
0.0	90.4	40.6	68.0	66.2	53.8	74.4	68.9	77.3
0.5	93.2	39.6	68.7	67.1	55.2	74.9	68.6	77.8
1.0	96.2	38.6	69.3	67.9	56.6	75.4	68.3	78.3
1.5	99.1	37.5	69.8	68.6	58.0	75.8	67.9	78.7
2.0	102.0	36.4	70.2	69.3	58.9	76.2	67.4	79.0
2.5	105.0	35.1	70.4	69.9	59.5	76.5	66.9	79.3
3.0	107.9	34.1	70.6	70.4	60.0	76.8	66.3	79.6
3.5	110.8	31.3	70.7	70.9	60.2	77.0	65.7	79.8
4.0	113.6	30.3	70.6	71.2	59.7	77.2	64.9	79.9
4.5	116.3	29.2	70.5	71.4	59.2	77.3	64.2	80.0
5.0	119.0	27.9	70.3	71.6	58.6	77.4	63.3	80.1
5.5	121.6	26.0	70.0	71.2	57.5	77.2	62.5	79.8
6.0	124.1	24.2	69.7	70.3	56.2	77.1	61.5	79.5
6.5	126.5	22.9	69.3	69.5	54.8	77.0	60.6	79.4
7.0	128.8	21.5	68.8	68.9	53.4	77.0	59.9	79.2
7.5	131.1	20.0	68.0	68.2	51.8	76.9	59.2	79.0
8.0	133.2	17.6	67.1	67.4	50.1	76.8	58.5	78.7
8.5	135.2	14.1	66.2	66.6	48.3	76.6	57.7	78.4
9.0	137.1	13.3	65.3	65.8	46.7	76.4	56.9	78.0
9.5	139.0	10.7	64.4	65.0	44.7	76.2	56.1	77.7
10.0	140.7	7.7	63.4	64.1	43.0	75.9	55.4	77.2
10.5	142.4	0.0	62.2	63.2	41.5	75.5	54.7	76.6
11.0	143.9	0.1	61.0	62.2	39.8	75.2	54.0	76.2
11.5	145.4	0.7	59.7	61.2	38.2	74.8	53.3	75.8
12.0	146.9	0.7	58.5	60.2	36.5	74.5	52.8	75.4
12.5	148.2	0.7	57.4	59.7	34.7	74.1	52.5	75.1
13.0	149.5	0.1	56.2	59.1	32.8	73.8	52.0	74.7
13.5	150.7	0.1	55.1	58.5	31.2	73.2	51.6	74.0
14.0	151.9	0.1	54.0	57.8	29.0	72.4	51.3	73.2
14.5	153.0	0.1	52.9	57.1	27.6	71.6	51.0	72.4
15.0	154.0	0.1	51.9	56.4	26.3	70.7	50.7	71.6
15.5	155.0	0.1	50.8	55.7	24.4	70.0	50.3	70.9
16.0	156.0	0.0	49.6	55.0	21.8	69.2	49.9	70.2
16.5	156.9	0.0	48.5	54.3	20.5	68.5	49.5	69.4

File: PNLT.TXT - Business Jet Component PNLT at 4′ Microphone for FAA Certification Conditions

Approach

TIME	EMANG	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
-4.5	27.6	80.4	59.0	68.4	65.2	74.5	85.4	87.5
-4.0	30.8	80.1	62.1	69.9	67.3	75.8	86.5	88.4
-3.5	34.9	79.0	65.6	71.9	69.6	77.6	88.1	89.5
-3.0	40.3	77.6	69.8	73.0	72.1	79.2	89.5	90.6
-2.5	47.6	74.6	74.3	74.9	74.6	81.2	90.9	92.1
-2.0	57.6	70.7	79.0	76.7	77.2	82.8	91.6	93.1
-1.5	70.9	67.0	86.7	77.7	79.6	84.7	91.5	94.5
-1.0	87.4	59.7	92.2	80.8	81.4	86.3	90.1	96.5
-0.5	105.0	47.6	93.9	84.0	86.5	87.2	86.8	97.9
0.0	120.8	33.3	93.3	85.4	85.3	86.5	82.7	97.1
0.5	133.3	14.8	90.6	81.9	78.7	83.9	78.8	94.1
1.0	142.4	1.2	86.2	77.3	72.5	81.3	75.1	90.1
1.5	149.2	0.0	81.5	73.2	67.5	78.6	72.6	86.1

Sideline

TIME	EMANG	INLET	AFTFAN	CORE	TURBINE	JET	AIRFRAME	TOTAL A/P
-6.0	50.9	67.6	52.4	64.8	44.7	71.4	69.8	76.2
-5.5	53.1	67.7	54.5	65.8	46.5	72.5	70.5	77.0
-5.0	55.4	67.7	56.8	66.6	48.1	73.5	71.3	77.8
-4.5	57.8	67.8	59.0	67.7	49.7	74.7	72.1	78.8
-4.0	60.5	67.7	61.1	68.7	51.3	75.8	72.8	79.6
-3.5	63.4	67.3	63.8	69.3	52.6	76.6	73.1	80.0
-3.0	66.4	67.0	66.4	69.9	53.8	77.4	73.2	81.6
-2.5	69.7	67.3	69.5	70.2	54.9	78.0	73.2	82.7
-2.0	73.1	66.0	71.6	70.4	55.9	78.9	73.4	83.5
-1.5	76.8	64.4	73.4	70.9	56.9	79.8	73.4	84.4
-1.0	80.6	62.6	75.2	71.5	57.7	80.6	73.3	85.2
-0.5	84.6	60.4	76.7	72.4	58.5	81.3	72.9	86.0
0.0	88.6	60.2	78.2	73.6	59.1	82.3	72.5	87.0
0.5	92.8	59.3	79.2	74.7	60.7	83.2	72.1	87.8
1.0	96.9	58.6	79.8	75.7	62.6	84.0	71.6	88.5
1.5	101.1	53.4	80.2	76.6	64.1	84.7	70.9	89.1
2.0	105.2	51.9	80.2	77.3	65.0	85.3	70.0	89.5
2.5	109.2	51.0	80.0	77.9	65.6	85.8	69.1	89.7
3.0	113.0	49.8	79.7	78.3	65.2	86.1	68.0	89.9
3.5	116.7	48.6	79.3	78.6	64.3	86.4	66.9	90.0
4.0	120.3	47.2	78.7	78.7	63.3	86.8	65.8	90.1
4.5	123.6	45.8	77.3	77.7	61.4	87.0	64.6	89.5
5.0	126.7	44.2	76.6	76.6	59.6	87.2	63.4	89.4
5.5	129.6	42.8	75.8	75.5	57.7	87.3	62.2	89.4
6.0	132.3	41.4	74.1	74.5	55.5	87.2	60.9	88.8
6.5	134.8	40.3	72.4	73.5	53.2	87.1	59.8	88.1
7.0	137.2	39.1	72.0	72.5	51.1	86.9	58.8	87.8
7.5	139.4	38.5	70.9	71.5	49.0	86.7	57.8	88.4
8.0	141.4	37.0	69.4	70.4	46.9	86.1	57.0	87.9
8.5	143.2	35.8	67.9	69.3	44.7	85.4	56.2	87.1
9.0	145.0	34.7	66.4	68.3	42.7	84.7	55.4	86.4
9.5	146.6	33.2	65.0	67.2	40.6	83.9	54.6	85.0
10.0	148.1	31.9	63.5	66.1	38.6	83.2	53.8	84.2
10.5	149.4	30.5	62.1	65.1	36.8	82.5	53.1	83.5
11.0	150.7	28.8	60.7	64.2	34.9	81.7	52.4	82.6
11.5	151.9	26.7	59.4	63.2	33.1	80.8	51.8	81.8
12.0	153.0	24.5	58.2	62.3	31.4	80.0	51.3	80.9
12.5	154.1	22.4	56.9	61.4	29.2	79.2	50.6	80.0

APPENDIX VIII

TABLES OF FLYOVER JET NOISE AND TOTAL NOISE DIFFERENCES FOR POROUS MIXER NOZZLE RELATIVE TO BASELINE NOZZLE

(37 Pages)

APPROACH

Delta = Porous - Reference

27.6 degrees BAND	**DELTA JET**	**DELTA TOTL**
17	-2.9	-2.9
18	-3.2	-3.2
19	-2.0	-2.0
20	-2.8	-2.8
21	-1.7	-1.7
22	-3.0	-3.0
23	-2.1	-2.1
24	-1.8	-1.8
25	-1.7	-1.7
26	-1.7	-1.7
27	-1.6	-1.3
28	-1.4	-0.7
29	-1.3	-0.5
30	-1.2	-0.4
31	-0.9	-0.2
32	-0.8	-0.1
33	-0.7	0.0
34	-0.8	0.0
35	-0.8	0.0
36	-1.0	0.0
37	-1.5	0.0
38	-2.2	0.0
39	-3.2	0.0
40	-4.9	0.0
30.8 degrees BAND	**DELTA JET**	**DELTA TOTL**
17	-2.9	-2.9
18	-2.9	-2.9
19	-1.7	-1.7
20	-2.6	-2.6
21	-1.7	-1.7
22	-3.0	-3.0
23	-2.2	-2.2
24	-1.9	-1.9
25	-1.8	-1.8
26	-1.8	-1.8
27	-1.7	-1.5
28	-1.5	-0.9
29	-1.3	-0.6
30	-1.2	-0.4
31	-1.0	-0.3
32	-0.9	-0.1
33	-0.8	0.0
34	-0.8	0.0
35	-0.8	0.0
36	-1.1	0.0
37	-1.6	0.0
38	-2.2	0.0
39	-3.3	0.0
40	-4.9	0.0
34.9 degrees BAND	**DELTA JET**	**DELTA TOTL**
17	-2.9	-2.9
18	-2.9	-2.9
19	-1.6	-1.6
20	-2.7	-2.7
21	-2.3	-2.3
22	-3.3	-3.3
23	-2.3	-2.3
24	-1.9	-1.9
25	-1.8	-1.8
26	-1.8	-1.8
27	-1.6	-1.6
28	-1.5	-0.9
29	-1.3	-0.7
30	-1.2	-0.5
31	-1.0	-0.3
32	-0.9	-0.2
33	-0.8	0.0
34	-0.8	0.0
35	-0.9	0.0
36	-1.1	0.0
37	-1.6	0.0
38	-2.3	0.0
39	-3.3	0.0
40	-4.9	-0.1

40.3 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-2.9	-2.9
18	-2.8	-2.8
19	-1.4	-1.4
20	-3.0	-3.0
21	-3.1	-3.1
22	-3.7	-3.7
23	-2.2	-2.2
24	-1.8	-1.8
25	-1.8	-1.8
26	-1.8	-1.8
27	-1.5	-1.6
28	-1.4	-1.1
29	-1.3	-0.8
30	-1.1	-0.5
31	-1.1	-0.3
32	-0.9	-0.2
33	-0.8	-0.1
34	-0.8	0.0
35	-0.9	0.0
36	-1.1	0.0
37	-1.6	0.0
38	-2.3	0.0
39	-3.3	0.0
40	-4.9	0.0
47.6 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-3.3	-3.3
18	-3.3	-3.3
19	-1.9	-1.9
20	-3.4	-3.4
21	-3.6	-3.6
22	-3.2	-3.2
23	-2.5	-2.5
24	-1.9	-1.9
25	-2.0	-2.0
26	-1.8	-1.8
27	-1.6	-1.5
28	-1.5	-1.1
29	-1.3	-0.9
30	-1.2	-0.6
31	-1.1	-0.3
32	-1.0	-0.2
33	-0.9	-0.1
34	-0.8	0.0
35	-0.9	-0.1
36	-1.1	0.0
37	-1.6	-0.1
38	-2.3	0.0
39	-3.3	0.0
40	-4.9	0.0
57.6 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-3.6	-3.6
18	-3.3	-3.3
19	-2.4	-2.4
20	-3.6	-3.6
21	-3.4	-3.4
22	-3.3	-3.3
23	-3.3	-3.3
24	-2.1	-2.1
25	-2.2	-2.2
26	-1.8	-1.8
27	-1.6	-1.6
28	-1.5	-1.5
29	-1.3	-1.1
30	-1.2	-0.8
31	-1.1	-0.5
32	-1.0	-0.3
33	-0.9	-0.1
34	-0.9	-0.1
35	-0.9	-0.1
36	-1.1	0.0
37	-1.6	0.0
38	-2.3	0.0
39	-3.3	0.0
40	-4.9	0.0

70.9 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-3.1	-3.1
18	-3.8	-3.8
19	-3.2	-3.2
20	-3.2	-3.2
21	-2.7	-2.7
22	-4.3	-4.3
23	-3.0	-3.0
24	-1.9	-1.9
25	-2.0	-2.0
26	-1.5	-1.5
27	-1.4	-1.4
28	-1.3	-1.2
29	-1.2	-1.1
30	-1.0	-0.8
31	-0.9	-0.6
32	-0.8	-0.4
33	-0.7	-0.1
34	-0.7	-0.1
35	-0.8	0.0
36	-1.0	0.0
37	-1.5	0.0
38	-2.2	0.0
39	-3.0	-0.1
40	-4.6	0.0
87.4 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-3.5	-3.5
18	-3.9	-3.9
19	-3.9	-3.9
20	-3.6	-3.6
21	-3.5	-3.5
22	-3.9	-3.9
23	-3.4	-3.4
24	-2.5	-2.5
25	-2.5	-2.5
26	-2.5	-2.5
27	-2.3	-2.3
28	-2.1	-2.0
29	-2.0	-1.8
30	-1.7	-1.4
31	-1.7	-1.1
32	-1.4	-0.6
33	-1.4	-0.2
34	-1.3	-0.1
35	-1.4	-0.1
36	-1.6	0.0
37	-2.0	-0.1
38	-2.7	0.0
39	-3.6	0.0
40	-5.2	0.0
105 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-4.0	-4.0
18	-4.5	-4.5
19	-4.2	-4.2
20	-3.8	-3.8
21	-3.4	-3.4
22	-4.3	-4.3
23	-4.0	-4.0
24	-2.8	-2.8
25	-2.8	-2.8
26	-2.6	-2.6
27	-2.5	-2.5
28	-2.3	-2.3
29	-2.2	-2.2
30	-2.0	-1.5
31	-1.8	-0.7
32	-1.7	-0.3
33	-1.6	-0.1
34	-1.7	0.0
35	-1.7	0.0
36	-2.0	0.0
37	-2.3	0.0
38	-2.9	0.0
39	-3.8	0.0
40	-5.4	0.0

120.8 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-4.4	-4.4
18	-4.5	-4.5
19	-4.7	-4.7
20	-4.2	-4.2
21	-4.0	-4.0
22	-5.1	-5.1
23	-4.3	-4.3
24	-3.5	-3.5
25	-3.7	-3.7
26	-3.5	-3.5
27	-3.4	-3.4
28	-3.4	-3.4
29	-3.5	-3.5
30	-3.3	-2.2
31	-3.1	-0.7
32	-3.0	-0.2
33	-2.9	-0.1
34	-2.9	0.0
35	-2.9	0.0
36	-3.1	0.0
37	-3.5	0.0
38	-4.1	0.0
39	-5.0	0.0
40	-6.4	0.0
133.3 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-4.6	-4.6
18	-4.4	-4.4
19	-4.8	-4.8
20	-4.5	-4.5
21	-4.3	-4.3
22	-5.1	-5.1
23	-4.5	-4.5
24	-3.8	-3.8
25	-3.9	-3.9
26	-3.6	-3.6
27	-3.3	-3.3
28	-3.2	-3.2
29	-3.0	-3.0
30	-3.0	-0.7
31	-2.9	-0.2
32	-2.8	0.0
33	-2.6	0.0
34	-2.6	0.0
35	-2.8	0.0
36	-3.0	0.0
37	-3.4	0.0
38	-4.0	0.0
39	-4.9	0.0
40	-6.2	0.0
142.4 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-4.8	-4.8
18	-4.7	-4.7
19	-4.9	-4.9
20	-4.6	-4.6
21	-4.4	-4.4
22	-5.1	-5.1
23	-4.7	-4.7
24	-4.1	-4.1
25	-4.0	-4.0
26	-3.4	-3.4
27	-3.1	-3.1
28	-2.9	-2.9
29	-2.6	-2.6
30	-2.5	-0.3
31	-2.4	0.0
32	-2.3	0.0
33	-2.2	0.0
34	-2.2	0.0
35	-2.3	0.0
36	-2.6	0.0
37	-2.8	0.0
38	-3.4	0.0
39	-4.3	0.0
40	-5.6	0.0

149.2 degrees BAND	DELTA JET	DELTA TOTL
17	-4.8	-4.8
18	-4.7	-4.7
19	-4.8	-4.8
20	-4.6	-4.6
21	-4.4	-4.4
22	-4.9	-4.9
23	-4.6	-4.6
24	-4.1	-4.1
25	-4.0	-4.0
26	-3.4	-3.4
27	-3.1	-3.1
28	-3.0	-3.0
29	-2.7	-2.7
30	-2.6	-0.2
31	-2.5	0.0
32	-2.2	0.0
33	-2.3	0.0
34	-2.2	0.0
35	-2.3	0.0
36	-2.5	0.0
37	-2.8	0.0
38	-3.5	0.0
39	-4.3	0.0
40	-0.4	0.0

CUTBACK TAKEOFF

Delta = Porous - Reference

48.8 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.5	-1.5
18	-2.4	-2.4
19	-2.3	-2.3
20	-2.3	-2.3
21	-2.3	-2.3
22	-2.5	-2.5
23	-2.3	-2.3
24	-2.4	-2.4
25	-2.8	-2.8
26	-2.8	-2.8
27	-3.0	-3.0
28	-2.8	-2.8
29	-2.5	-2.5
30	-2.0	-2.0
31	-2.0	-2.0
32	-1.9	-1.6
33	-2.0	-0.4
34	-2.1	-0.1
35	-2.1	-0.1
36	-2.0	-0.2
37	-1.8	-0.1
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
50.0 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.6	-1.6
18	-2.4	-2.4
19	-2.3	-2.3
20	-2.2	-2.2
21	-2.3	-2.3
22	-2.5	-2.5
23	-2.4	-2.4
24	-2.5	-2.5
25	-2.9	-2.9
26	-3.0	-3.0
27	-3.0	-3.0
28	-2.9	-2.5
29	-2.4	-2.4
30	-2.0	-2.0
31	-2.1	-2.1
32	-1.9	-1.6
33	-2.0	-0.4
34	-2.2	-0.1
35	-2.1	-0.1
36	-2.2	-0.1
37	-1.8	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
51.2 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.7	-1.7
18	-2.4	-2.4
19	-2.3	-2.3
20	-2.2	-2.2
21	-2.3	-2.3
22	-2.6	-2.6
23	-2.4	-2.4
24	-2.5	-2.5
25	-2.9	-2.9
26	-3.0	-3.0
27	-3.1	-3.1
28	-3.0	-2.8
29	-2.5	-2.5
30	-2.0	-2.0
31	-2.1	-2.1
32	-2.0	-1.7
33	-2.0	-0.4
34	-2.2	-0.1
35	-2.2	0.0
36	-2.2	-0.2
37	-1.8	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0

52.5 degrees BAND	DELTA JET	DELTA TOTL
17	-1.7	-1.7
18	-2.3	-2.3
19	-2.3	-2.3
20	-2.3	-2.3
21	-2.4	-2.4
22	-2.7	-2.7
23	-2.5	-2.5
24	-2.6	-2.6
25	-2.9	-2.9
26	-3.0	-3.0
27	-3.0	-3.0
28	-3.0	-3.0
29	-2.5	-2.5
30	-2.1	-2.1
31	-2.1	-2.1
32	-2.0	-1.7
33	-2.1	-0.4
34	-2.2	-0.1
35	-2.2	-0.1
36	-2.2	-0.2
37	-1.8	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
53.9 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.7	-1.7
18	-2.3	-2.3
19	-2.4	-2.4
20	-2.3	-2.3
21	-2.4	-2.4
22	-2.7	-2.7
23	-2.5	-2.5
24	-2.6	-2.6
25	-2.9	-2.9
26	-3.1	-3.1
27	-3.0	-3.0
28	-3.0	-3.0
29	-2.6	-2.6
30	-2.1	-2.1
31	-2.1	-2.1
32	-2.1	-1.7
33	-2.1	-0.5
34	-2.3	-0.1
35	-2.3	-0.1
36	-2.2	-0.1
37	-1.9	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
55.3 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.7	-1.7
18	-2.2	-2.2
19	-2.4	-2.4
20	-2.4	-2.4
21	-2.5	-2.5
22	-2.7	-2.7
23	-2.6	-2.6
24	-2.6	-2.6
25	-2.9	-2.9
26	-3.1	-3.1
27	-3.0	-3.0
28	-3.0	-3.0
29	-2.6	-2.5
30	-2.0	-2.0
31	-2.2	-2.2
32	-2.1	-1.7
33	-2.1	-0.5
34	-2.3	-0.2
35	-2.2	-0.1
36	-2.2	-0.1
37	-1.9	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0

56.8 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.8	-1.8
18	-2.2	-2.2
19	-2.3	-2.3
20	-2.5	-2.5
21	-2.5	-2.5
22	-2.7	-2.7
23	-2.7	-2.7
24	-2.7	-2.7
25	-2.9	-2.9
26	-3.1	-3.1
27	-3.1	-3.1
28	-3.0	-3.0
29	-2.5	-2.5
30	-2.1	-2.1
31	-2.1	-2.1
32	-2.1	-1.8
33	-2.2	-0.5
34	-2.2	-0.2
35	-2.3	0.0
36	-2.2	-0.2
37	-2.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
58.4 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.8	-1.8
18	-2.2	-2.2
19	-2.3	-2.3
20	-2.5	-2.5
21	-2.6	-2.6
22	-2.8	-2.8
23	-2.7	-2.7
24	-2.7	-2.7
25	-2.9	-2.9
26	-3.1	-3.1
27	-3.1	-3.1
28	-3.0	-3.0
29	-2.5	-2.5
30	-2.1	-2.1
31	-2.1	-2.1
32	-2.1	-1.8
33	-2.2	-0.6
34	-2.3	-0.2
35	-2.4	-0.1
36	-2.3	-0.2
37	-2.0	0.0
38	-1.2	-0.1
39	0.0	0.0
40	0.0	0.0
60.1 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.8	-1.8
18	-2.1	-2.1
19	-2.3	-2.3
20	-2.6	-2.6
21	-2.7	-2.7
22	-2.9	-2.9
23	-2.8	-2.8
24	-2.7	-2.7
25	-2.9	-2.9
26	-3.2	-3.2
27	-3.1	-3.1
28	-3.1	-3.1
29	-2.5	-2.5
30	-2.2	-2.2
31	-2.2	-2.1
32	-2.2	-1.8
33	-2.3	-0.6
34	-2.3	-0.1
35	-2.4	-0.1
36	-2.3	-0.1
37	-2.0	0.0
38	-1.6	-0.1
39	0.0	0.0
40	0.0	0.0

61.9 degrees BAND	DELTA JET	DELTA TOTL
17	-1.8	-1.8
18	-2.1	-2.1
19	-2.3	-2.4
20	-2.6	-2.6
21	-2.7	-2.7
22	-2.8	-2.8
23	-2.8	-2.8
24	-2.8	-2.8
25	-2.9	-2.9
26	-3.2	-3.2
27	-3.1	-3.1
28	-3.0	-3.0
29	-2.6	-2.6
30	-2.1	-2.1
31	-2.1	-2.2
32	-2.2	-1.9
33	-2.2	-0.6
34	-2.3	-0.2
35	-2.4	-0.1
36	-2.3	-0.2
37	-2.0	-0.1
38	-1.5	0.0
39	0.0	0.0
40	0.0	0.0
63.7 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.8	-1.8
18	-2.1	-2.1
19	-2.4	-2.4
20	-2.5	-2.5
21	-2.6	-2.6
22	-2.7	-2.7
23	-2.8	-2.8
24	-2.8	-2.8
25	-2.8	-2.8
26	-3.1	-3.1
27	-3.0	-3.0
28	-3.1	-3.1
29	-2.6	-2.6
30	-2.1	-2.1
31	-2.2	-2.1
32	-2.2	-1.9
33	-2.2	-0.6
34	-2.3	-0.3
35	-2.3	-0.2
36	-2.2	-0.3
37	-1.9	-0.1
38	-1.5	-0.1
39	0.0	0.0
40	0.0	0.0
65.7 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.7	-1.7
18	-2.0	-2.0
19	-2.4	-2.4
20	-2.6	-2.6
21	-2.6	-2.6
22	-2.6	-2.6
23	-2.7	-2.7
24	-2.8	-2.8
25	-2.8	-2.8
26	-3.0	-3.0
27	-3.0	-3.0
28	-3.0	-3.0
29	-2.6	-2.6
30	-2.1	-2.1
31	-2.2	-2.1
32	-2.1	-1.9
33	-2.2	-0.7
34	-2.3	-0.2
35	-2.4	-0.2
36	-2.2	-0.3
37	-2.0	-0.1
38	-1.4	-0.1
39	0.0	0.0
40	0.0	0.0

67.7 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.8	-1.8
18	-2.0	-2.0
19	-2.4	-2.4
20	-2.5	-2.5
21	-2.7	-2.7
22	-2.6	-2.6
23	-2.6	-2.6
24	-2.8	-2.8
25	-2.8	-2.8
26	-2.9	-2.9
27	-2.9	-2.9
28	-2.9	-2.9
29	-2.6	-2.6
30	-2.1	-2.1
31	-2.1	-2.1
32	-2.1	-1.9
33	-2.1	-0.6
34	-2.2	-0.3
35	-2.3	-0.2
36	-2.2	-0.3
37	-1.9	0.0
38	-1.5	-0.1
39	0.0	0.0
40	0.0	0.0
69.9 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.8	-1.8
18	-2.0	-2.0
19	-2.3	-2.3
20	-2.5	-2.5
21	-2.7	-2.7
22	-2.5	-2.5
23	-2.6	-2.6
24	-2.9	-2.9
25	-2.8	-2.8
26	-2.9	-2.9
27	-2.8	-2.8
28	-2.9	-2.9
29	-2.6	-2.6
30	-2.0	-2.0
31	-2.1	-2.1
32	-2.1	-1.8
33	-2.2	-0.6
34	-2.3	-0.3
35	-2.3	-0.3
36	-2.2	-0.4
37	-1.9	-0.1
38	-1.4	-0.1
39	0.0	0.0
40	0.0	0.0
72.1 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.8	-1.8
18	-1.9	-1.9
19	-2.3	-2.3
20	-2.5	-2.5
21	-2.7	-2.7
22	-2.6	-2.6
23	-2.7	-2.7
24	-2.8	-2.8
25	-2.8	-2.8
26	-2.8	-2.8
27	-2.9	-2.9
28	-2.9	-2.9
29	-2.5	-2.5
30	-2.1	-2.1
31	-2.1	-2.0
32	-2.1	-1.8
33	-2.1	-0.7
34	-2.3	-0.3
35	-2.4	-0.3
36	-2.3	-0.3
37	-1.9	0.0
38	-1.4	-0.1
39	0.0	0.0
40	0.0	0.0

74.5 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.8	-1.8
18	-1.9	-1.9
19	-2.3	-2.3
20	-2.5	-2.5
21	-2.6	-2.6
22	-2.5	-2.5
23	-2.6	-2.6
24	-2.8	-2.8
25	-2.8	-2.8
26	-2.9	-2.9
27	-2.9	-2.9
28	-2.9	-2.9
29	-2.6	-2.6
30	-2.1	-2.1
31	-2.1	-2.1
32	-2.1	-1.7
33	-2.2	-0.7
34	-2.3	-0.4
35	-2.3	-0.3
36	-2.3	-0.3
37	-1.9	0.0
38	-1.4	-0.1
39	0.0	0.0
40	0.0	0.0
76.9 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.8	-1.8
18	-2.0	-2.0
19	-2.3	-2.3
20	-2.5	-2.5
21	-2.6	-2.6
22	-2.6	-2.6
23	-2.7	-2.7
24	-2.8	-2.8
25	-2.8	-2.8
26	-2.8	-2.8
27	-2.9	-2.9
28	-3.0	-3.0
29	-2.5	-2.5
30	-2.1	-2.1
31	-2.1	-2.0
32	-2.1	-1.8
33	-2.2	-0.7
34	-2.3	-0.4
35	-2.3	-0.4
36	-2.3	-0.2
37	-2.0	0.0
38	-1.4	0.0
39	0.0	0.0
40	0.0	0.0
79.4 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.8	-1.8
18	-2.0	-2.0
19	-2.3	-2.3
20	-2.6	-2.6
21	-2.6	-2.6
22	-2.6	-2.6
23	-2.7	-2.7
24	-2.7	-2.7
25	-2.7	-2.7
26	-2.8	-2.8
27	-2.9	-2.9
28	-3.0	-2.9
29	-2.5	-2.5
30	-2.1	-2.1
31	-2.0	-1.9
32	-2.1	-1.7
33	-2.2	-0.7
34	-2.3	-0.5
35	-2.3	-0.4
36	-2.4	-0.1
37	-2.1	0.0
38	-1.4	-0.1
39	0.0	0.0
40	0.0	0.0

82.1 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.8	-1.8
18	-1.9	-1.9
19	-2.3	-2.3
20	-2.6	-2.6
21	-2.6	-2.6
22	-2.6	-2.6
23	-2.8	-2.8
24	-2.8	-2.8
25	-2.7	-2.7
26	-2.8	-2.8
27	-2.9	-2.9
28	-2.9	-2.9
29	-2.6	-2.6
30	-2.1	-2.1
31	-2.1	-2.0
32	-2.2	-1.9
33	-2.2	-0.8
34	-2.3	-0.9
35	-2.4	-0.5
36	-2.3	-0.1
37	-2.1	0.0
38	-1.4	-0.1
39	0.0	0.0
40	0.0	0.0
84.8 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.6	-1.6
18	-1.9	-1.9
19	-2.2	-2.2
20	-2.6	-2.6
21	-2.6	-2.6
22	-2.6	-2.6
23	-2.8	-2.8
24	-2.7	-2.7
25	-2.7	-2.7
26	-2.8	-2.8
27	-2.9	-2.9
28	-2.9	-2.9
29	-2.6	-2.6
30	-2.2	-2.2
31	-2.2	-2.0
32	-2.2	-1.9
33	-2.3	-0.8
34	-2.3	-1.1
35	-2.4	-0.6
36	-2.4	0.0
37	-2.1	-0.1
38	-1.4	0.0
39	-0.3	0.0
40	0.0	0.0
87.5 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.6	-1.6
18	-1.9	-1.9
19	-2.2	-2.2
20	-2.6	-2.6
21	-2.7	-2.7
22	-2.7	-2.7
23	-2.7	-2.7
24	-2.7	-2.7
25	-2.7	-2.7
26	-2.8	-2.8
27	-2.8	-2.8
28	-2.9	-2.9
29	-2.6	-2.6
30	-2.3	-2.3
31	-2.2	-2.1
32	-2.2	-1.8
33	-2.2	-0.9
34	-2.4	-1.0
35	-2.4	-0.6
36	-2.4	0.0
37	-2.1	-0.1
38	-1.5	-0.1
39	-0.8	0.0
40	0.0	0.0

90.4 degrees	DELTA	DELTA
BAND	**JET**	**TOTL**
17	-1.6	-1.6
18	-2.0	-2.0
19	-2.2	-2.2
20	-2.7	-2.7
21	-2.7	-2.7
22	-2.7	-2.7
23	-2.8	-2.8
24	-2.6	-2.6
25	-2.6	-2.6
26	-2.8	-2.8
27	-2.9	-2.9
28	-2.8	-2.8
29	-2.6	-2.6
30	-2.2	-2.2
31	-2.2	-2.1
32	-2.2	-1.6
33	-2.2	-0.6
34	-2.4	-0.7
35	-2.4	-0.4
36	-2.3	0.0
37	-2.1	-0.1
38	-1.5	0.0
39	-0.8	0.0
40	0.0	0.0

93.2 degrees	DELTA	DELTA
BAND	**JET**	**TOTL**
17	-1.6	-1.6
18	-2.0	-2.0
19	-2.3	-2.3
20	-2.7	-2.7
21	-2.6	-2.6
22	-2.6	-2.6
23	-2.8	-2.8
24	-2.7	-2.7
25	-2.7	-2.7
26	-2.8	-2.8
27	-2.8	-2.8
28	-2.8	-2.8
29	-2.5	-2.5
30	-2.2	-2.2
31	-2.2	-2.1
32	-2.1	-1.6
33	-2.2	-1.0
34	-2.3	-0.6
35	-2.5	-0.4
36	-2.3	0.0
37	-2.1	-0.1
38	-1.4	0.0
39	-0.7	-0.1
40	0.0	0.0

96.2 degrees	DELTA	DELTA
BAND	**JET**	**TOTL**
17	-1.6	-1.6
18	-2.0	-2.0
19	-2.5	-2.5
20	-2.8	-2.8
21	-2.5	-2.5
22	-2.6	-2.6
23	-2.8	-2.8
24	-2.7	-2.7
25	-2.8	-2.8
26	-2.8	-2.8
27	-2.9	-2.9
28	-2.8	-2.8
29	-2.5	-2.5
30	-2.2	-2.2
31	-2.1	-2.0
32	-2.0	-1.5
33	-2.1	-0.9
34	-2.3	-0.6
35	-2.3	-0.4
36	-2.3	-0.1
37	-2.0	-0.1
38	-1.4	-0.1
39	-0.6	0.0
40	0.0	0.0

99.1 degrees BAND	DELTA JET	DELTA TOTL
17	-1.7	-1.7
18	-2.1	-2.1
19	-2.7	-2.7
20	-2.9	-2.9
21	-2.5	-2.5
22	-2.6	-2.6
23	-2.8	-2.8
24	-2.7	-2.7
25	-2.9	-2.9
26	-2.9	-2.9
27	-2.9	-2.9
28	-2.7	-2.7
29	-2.4	-2.4
30	-2.1	-2.1
31	-2.1	-2.0
32	-2.0	-1.4
33	-2.1	-0.8
34	-2.2	-0.5
35	-2.3	-0.4
36	-2.1	0.0
37	-2.0	-0.1
38	-1.3	0.0
39	-0.5	0.0
40	0.0	0.0

102 degrees BAND	DELTA JET	DELTA TOTL
17	-1.8	-1.8
18	-2.3	-2.3
19	-2.9	-2.9
20	-3.0	-3.0
21	-2.6	-2.6
22	-2.6	-2.6
23	-2.8	-2.8
24	-2.8	-2.8
25	-2.9	-2.9
26	-3.0	-3.0
27	-3.0	-3.0
28	-2.7	-2.7
29	-2.4	-2.4
30	-2.0	-2.0
31	-2.0	-2.0
32	-2.0	-1.4
33	-2.1	-0.7
34	-2.2	-0.6
35	-2.2	-0.3
36	-2.1	0.0
37	-1.9	0.0
38	-1.3	0.0
39	-0.5	0.0
40	0.0	0.0

105 degrees BAND	DELTA JET	DELTA TOTL
17	-2.0	-2.0
18	-2.5	-2.5
19	-3.1	-3.1
20	-3.2	-3.2
21	-2.8	-2.8
22	-2.8	-2.8
23	-3.0	-3.0
24	-2.9	-2.9
25	-3.1	-3.1
26	-3.1	-3.1
27	-3.0	-3.0
28	-2.7	-2.7
29	-2.4	-2.4
30	-2.0	-2.0
31	-1.9	-1.9
32	-1.9	-1.4
33	-2.0	-0.7
34	-2.1	-0.4
35	-2.1	-0.3
36	-2.0	0.0
37	-1.8	0.0
38	-1.2	0.0
39	-0.3	0.0
40	0.0	0.0

107.9 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-2.1	-2.1
18	-2.6	-2.6
19	-3.3	-3.3
20	-3.3	-3.3
21	-3.0	-3.0
22	-3.0	-3.0
23	-3.1	-3.1
24	-3.1	-3.1
25	-3.2	-3.2
26	-3.2	-3.2
27	-3.1	-3.1
28	-2.8	-2.8
29	-2.4	-2.4
30	-1.8	-1.8
31	-1.8	-1.8
32	-1.8	-1.4
33	-1.9	-0.6
34	-2.1	-0.5
35	-2.0	-0.3
36	-2.0	0.0
37	-1.7	-0.1
38	-1.1	0.0
39	-0.3	0.0
40	0.0	0.0
110.8 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.3	-2.3
18	-2.8	-2.8
19	-3.5	-3.5
20	-3.6	-3.6
21	-3.2	-3.2
22	-3.2	-3.2
23	-3.2	-3.2
24	-3.2	-3.2
25	-3.3	-3.3
26	-3.3	-3.3
27	-3.2	-3.2
28	-2.8	-2.8
29	-2.3	-2.3
30	-1.9	-1.9
31	-1.8	-1.8
32	-1.7	-1.3
33	-1.9	-0.5
34	-2.1	-0.5
35	-2.0	-0.2
36	-1.9	0.0
37	-1.7	-0.1
38	-1.0	0.0
39	-0.1	0.0
40	0.0	0.0
113.6 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.4	-2.4
18	-3.0	-3.0
19	-3.7	-3.7
20	-3.7	-3.7
21	-3.3	-3.3
22	-3.3	-3.3
23	-3.2	-3.2
24	-3.3	-3.3
25	-3.4	-3.4
26	-3.4	-3.4
27	-3.3	-3.3
28	-2.9	-2.9
29	-2.4	-2.4
30	-1.9	-1.9
31	-1.8	-1.8
32	-1.8	-1.3
33	-1.9	-0.6
34	-2.0	-0.4
35	-2.0	-0.2
36	-1.9	0.0
37	-1.7	0.0
38	-1.1	0.0
39	0.0	0.0
40	0.0	0.0

116.3 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-2.4	-2.4
18	-3.1	-3.1
19	-3.8	-3.8
20	-3.8	-3.8
21	-3.4	-3.4
22	-3.4	-3.4
23	-3.2	-3.2
24	-3.3	-3.3
25	-3.5	-3.5
26	-3.6	-3.6
27	-3.5	-3.5
28	-3.1	-3.1
29	-2.5	-2.5
30	-2.0	-2.0
31	-1.8	-1.8
32	-1.8	-1.3
33	-1.9	-0.5
34	-2.0	-0.4
35	-2.0	-0.2
36	-2.0	0.0
37	-1.6	-0.1
38	-1.1	0.0
39	0.0	0.0
40	0.0	0.0
119 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-2.6	-2.6
18	-3.3	-3.3
19	-4.0	-4.0
20	-3.9	-3.9
21	-3.5	-3.5
22	-3.5	-3.5
23	-3.3	-3.3
24	-3.5	-3.5
25	-3.6	-3.6
26	-3.7	-3.7
27	-3.6	-3.6
28	-3.2	-3.2
29	-2.6	-2.6
30	-2.0	-2.0
31	-1.8	-1.8
32	-1.8	-1.3
33	-1.8	-0.4
34	-2.0	-0.4
35	-2.0	-0.2
36	-2.0	0.0
37	-1.7	-0.1
38	-1.0	0.0
39	0.0	0.0
40	0.0	0.0
121.6 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-2.7	-2.7
18	-3.4	-3.4
19	-4.1	-4.1
20	-4.2	-4.2
21	-3.8	-3.8
22	-3.7	-3.7
23	-3.5	-3.5
24	-3.6	-3.6
25	-3.7	-3.7
26	-3.8	-3.8
27	-3.7	-3.7
28	-3.3	-3.3
29	-2.6	-2.6
30	-2.0	-2.0
31	-1.8	-1.8
32	-1.8	-1.2
33	-1.9	-0.4
34	-2.0	-0.3
35	-2.0	-0.2
36	-2.0	0.0
37	-1.7	0.0
38	-1.1	0.0
39	0.0	0.0
40	0.0	0.0

124.1 degrees BAND	DELTA JET	DELTA TOTL
17	-2.8	-2.8
18	-3.5	-3.5
19	-4.3	-4.3
20	-4.4	-4.4
21	-4.1	-4.1
22	-4.0	-4.0
23	-3.7	-3.7
24	-3.8	-3.8
25	-3.9	-3.9
26	-3.8	-3.8
27	-3.8	-3.8
28	-3.3	-3.3
29	-2.6	-2.6
30	-2.0	-2.0
31	-1.8	-1.8
32	-1.9	-1.1
33	-2.0	-0.5
34	-2.0	-0.3
35	-2.1	-0.2
36	-2.1	0.0
37	-1.8	0.0
38	-1.2	-0.1
39	0.0	0.0
40	0.0	0.0
126.5 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.7	-2.7
18	-3.7	-3.7
19	-4.5	-4.5
20	-4.5	-4.5
21	-4.3	-4.3
22	-4.3	-4.3
23	-3.9	-3.9
24	-3.9	-3.9
25	-4.0	-4.0
26	-3.8	-3.8
27	-3.8	-3.8
28	-3.3	-3.3
29	-2.5	-2.5
30	-2.0	-2.0
31	-1.9	-1.9
32	-1.9	-0.9
33	-2.0	-0.4
34	-2.0	-0.3
35	-2.1	-0.1
36	-2.1	0.0
37	-1.8	-0.1
38	-1.2	0.0
39	0.0	0.0
40	0.0	0.0
128.8 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.8	-2.8
18	-3.8	-3.8
19	-4.7	-4.7
20	-4.7	-4.7
21	-4.7	-4.7
22	-4.6	-4.6
23	-4.1	-4.1
24	-4.0	-4.0
25	-4.0	-4.0
26	-3.9	-3.9
27	-3.8	-3.8
28	-3.3	-3.3
29	-2.6	-2.6
30	-2.1	-2.1
31	-1.8	-1.8
32	-2.0	-0.9
33	-2.1	-0.4
34	-2.1	-0.3
35	-2.1	-0.1
36	-2.1	0.0
37	-1.8	0.0
38	-1.1	0.0
39	0.0	0.0
40	0.0	0.0

131.1 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.8	-2.8
18	-3.9	-3.9
19	-4.8	-4.8
20	-5.0	-5.0
21	-4.9	-4.9
22	-4.8	-4.8
23	-4.3	-4.3
24	-4.2	-4.2
25	-4.2	-4.2
26	-3.9	-3.9
27	-3.7	-3.7
28	-3.3	-3.3
29	-2.5	-2.5
30	-2.0	-2.0
31	-1.8	-1.7
32	-2.0	-0.7
33	-2.1	-0.4
34	-2.1	-0.2
35	-2.2	-0.1
36	-2.1	0.0
37	-1.8	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
133.2 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.8	-2.8
18	-4.0	-4.0
19	-4.9	-4.9
20	-5.3	-5.3
21	-5.2	-5.2
22	-5.0	-5.0
23	-4.6	-4.6
24	-4.3	-4.3
25	-4.3	-4.3
26	-4.0	-4.0
27	-3.8	-3.8
28	-3.2	-3.2
29	-2.4	-2.4
30	-1.9	-1.9
31	-1.7	-1.7
32	-1.9	-0.5
33	-2.0	-0.2
34	-2.0	-0.1
35	-2.1	0.0
36	-2.0	0.0
37	-1.7	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
135.2 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.8	-2.8
18	-3.9	-3.9
19	-5.1	-5.1
20	-5.5	-5.5
21	-5.5	-5.5
22	-5.3	-5.3
23	-4.8	-4.8
24	-4.5	-4.5
25	-4.4	-4.4
26	-4.0	-4.0
27	-3.7	-3.7
28	-3.1	-3.1
29	-2.3	-2.3
30	-1.7	-1.7
31	-1.6	-1.6
32	-1.8	-0.3
33	-1.9	-0.2
34	-2.0	-0.1
35	-2.1	-0.1
36	-2.0	0.0
37	-1.7	-0.1
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0

137.1 degrees	DELTA	DELTA
BAND	**JET**	**TOTL**
17	-2.8	-2.8
18	-4.0	-4.0
19	-5.2	-5.2
20	-5.7	-5.7
21	-5.8	-5.8
22	-5.5	-5.5
23	-5.1	-5.1
24	-4.7	-4.7
25	-4.5	-4.5
26	-4.1	-4.1
27	-3.7	-3.7
28	-3.1	-3.1
29	-2.2	-2.2
30	-1.6	-1.6
31	-1.7	-1.5
32	-1.8	-0.3
33	-1.8	-0.2
34	-1.9	-0.1
35	-2.1	0.0
36	-1.9	0.0
37	-0.8	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
139 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.8	-2.8
18	-4.0	-4.0
19	-5.3	-5.3
20	-6.0	-6.0
21	-6.1	-6.1
22	-5.7	-5.7
23	-5.3	-5.3
24	-4.8	-4.8
25	-4.5	-4.5
26	-4.1	-4.1
27	-3.7	-3.7
28	-3.0	-3.0
29	-2.1	-2.1
30	-1.4	-1.4
31	-1.6	-1.4
32	-1.7	-0.2
33	-1.7	-0.1
34	-1.8	-0.1
35	-2.0	0.0
36	-1.9	0.0
37	0.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
140.7 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.7	-2.7
18	-4.0	-4.0
19	-5.5	-5.5
20	-6.2	-6.2
21	-6.2	-6.2
22	-5.9	-5.9
23	-5.5	-5.5
24	-4.9	-4.9
25	-4.6	-4.6
26	-4.2	-4.2
27	-3.6	-3.6
28	-3.0	-3.0
29	-2.1	-2.1
30	-1.3	-1.4
31	-1.5	-1.2
32	-1.6	-0.1
33	-1.7	-0.1
34	-1.8	-0.1
35	-1.9	0.0
36	-1.9	0.0
37	0.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0

142.4 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.7	-2.7
18	-4.0	-4.0
19	-5.4	-5.4
20	-6.2	-6.2
21	-6.3	-6.3
22	-6.0	-6.0
23	-5.5	-5.5
24	-4.9	-4.9
25	-4.6	-4.6
26	-4.1	-4.1
27	-3.6	-3.6
28	-3.0	-3.0
29	-2.1	-2.1
30	-1.4	-1.4
31	-1.5	-1.0
32	-1.6	-0.1
33	-1.7	0.0
34	-1.7	0.0
35	-1.9	0.0
36	-0.4	0.0
37	0.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
143.9 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.6	-2.6
18	-3.9	-3.9
19	-5.4	-5.4
20	-6.2	-6.2
21	-6.3	-6.3
22	-6.1	-6.1
23	-5.6	-5.6
24	-4.9	-4.9
25	-4.7	-4.7
26	-4.2	-4.2
27	-3.6	-3.6
28	-3.0	-3.0
29	-2.1	-2.1
30	-1.4	-1.4
31	-1.5	-0.8
32	-1.6	-0.1
33	-1.6	0.0
34	-1.7	0.0
35	-1.8	0.0
36	0.0	0.0
37	0.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
145.4 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.6	-2.6
18	-3.9	-3.9
19	-5.4	-5.4
20	-6.2	-6.2
21	-6.3	-6.3
22	-6.1	-6.1
23	-5.7	-5.7
24	-5.0	-5.0
25	-4.8	-4.8
26	-4.2	-4.2
27	-3.6	-3.6
28	-3.0	-3.0
29	-2.2	-2.2
30	-1.3	-1.3
31	-1.5	-0.6
32	-1.6	-0.1
33	-1.6	-0.1
34	-1.6	0.0
35	-1.8	0.0
36	0.0	0.0
37	0.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0

146.9 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-2.6	-2.6
18	-3.8	-3.8
19	-5.5	-5.5
20	-6.3	-6.3
21	-6.4	-6.4
22	-6.2	-6.2
23	-5.8	-5.8
24	-5.1	-5.1
25	-4.8	-4.8
26	-4.2	-4.2
27	-3.6	-3.6
28	-3.1	-3.1
29	-2.1	-2.1
30	-1.3	-1.2
31	-1.4	-0.5
32	-1.5	-0.1
33	-1.6	-0.1
34	-1.7	0.0
35	-1.7	0.0
36	0.0	0.0
37	0.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
148.2 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-2.4	-2.4
18	-3.8	-3.8
19	-5.5	-5.5
20	-6.3	-6.3
21	-6.4	-6.4
22	-6.3	-6.3
23	-5.9	-5.9
24	-5.1	-5.1
25	-4.8	-4.8
26	-4.1	-4.1
27	-3.6	-3.6
28	-3.1	-3.1
29	-2.2	-2.2
30	-1.3	-1.2
31	-1.5	-0.3
32	-1.5	0.0
33	-1.4	0.0
34	-1.6	-0.1
35	-1.7	0.0
36	0.0	0.0
37	0.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
149.5 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-2.5	-2.5
18	-3.8	-3.8
19	-5.4	-5.4
20	-6.3	-6.3
21	-6.5	-6.5
22	-6.4	-6.4
23	-5.9	-5.9
24	-5.1	-5.1
25	-4.8	-4.8
26	-4.2	-4.2
27	-3.7	-3.7
28	-3.0	-3.0
29	-2.1	-2.1
30	-1.3	-0.7
31	-1.5	-0.3
32	-1.4	0.0
33	-1.4	-0.1
34	-1.6	0.0
35	-1.2	-0.1
36	0.0	0.0
37	0.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0

150.7 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.4	-2.4
18	-3.8	-3.8
19	-5.5	-5.5
20	-6.4	-6.3
21	-6.5	-6.5
22	-6.4	-6.4
23	-5.9	-5.9
24	-5.1	-5.1
25	-4.9	-4.9
26	-4.2	-4.2
27	-3.7	-3.7
28	-3.1	-3.1
29	-2.2	-2.2
30	-1.3	-0.5
31	-1.5	-0.2
32	-1.5	0.0
33	-1.5	0.0
34	-1.7	0.0
35	0.0	0.0
36	0.0	0.0
37	0.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
151.9 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.4	-2.4
18	-3.8	-3.8
19	-5.5	-5.5
20	-6.3	-6.3
21	-6.4	-6.4
22	-6.4	-6.4
23	-5.9	-5.9
24	-5.1	-5.1
25	-4.9	-4.9
26	-4.1	-4.1
27	-3.7	-3.7
28	-3.1	-3.1
29	-2.4	-2.3
30	-1.5	-0.7
31	-1.7	-0.2
32	-1.6	-0.1
33	-1.6	-0.1
34	-1.7	0.0
35	0.0	0.0
36	0.0	0.0
37	0.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
153.0 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.5	-2.5
18	-3.8	-3.8
19	-5.5	-5.5
20	-6.3	-6.3
21	-6.4	-6.4
22	-6.4	-6.4
23	-5.9	-5.9
24	-5.0	-5.0
25	-4.9	-4.9
26	-4.2	-4.2
27	-3.7	-3.7
28	-3.1	-3.1
29	-2.4	-2.3
30	-1.7	-0.7
31	-1.8	-0.2
32	-1.7	0.0
33	-1.7	0.0
34	-1.9	0.0
35	0.0	0.0
36	0.0	0.0
37	0.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0

154.0 degrees BAND	DELTA JET	DELTA TOTL
17	-2.4	-2.4
18	-3.8	-3.8
19	-5.5	-5.5
20	-6.3	-6.3
21	-6.3	-6.3
22	-6.4	-6.4
23	-5.9	-5.9
24	-5.1	-5.1
25	-4.9	-4.9
26	-4.1	-4.1
27	-3.7	-3.7
28	-3.2	-3.2
29	-2.5	-2.4
30	-1.7	-0.8
31	-1.8	-0.2
32	-1.9	0.0
33	-1.9	0.0
34	-2.0	0.0
35	0.0	0.0
36	0.0	0.0
37	0.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0

155.0 degrees BAND	DELTA JET	DELTA TOTL
17	-2.4	-2.4
18	-3.7	-3.7
19	-5.5	-5.5
20	-6.3	-6.3
21	-6.4	-6.4
22	-6.4	-6.4
23	-5.9	-5.9
24	-5.0	-5.0
25	-4.9	-4.9
26	-4.1	-4.1
27	-3.8	-3.7
28	-3.2	-3.2
29	-2.5	-2.5
30	-1.9	-0.9
31	-2.0	-0.2
32	-2.0	-0.1
33	-2.0	0.0
34	-2.1	0.0
35	0.0	0.0
36	0.0	0.0
37	0.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0

156.0 degrees BAND	DELTA JET	DELTA TOTL
17	-2.4	-2.4
18	-3.8	-3.8
19	-5.5	-5.5
20	-6.3	-6.3
21	-6.4	-6.4
22	-6.4	-6.4
23	-5.8	-5.8
24	-5.0	-5.0
25	-4.9	-4.9
26	-4.0	-4.0
27	-3.8	-3.8
28	-3.2	-3.2
29	-2.6	-2.6
30	-2.0	-1.0
31	-2.1	-0.2
32	-2.0	0.0
33	-2.2	0.0
34	-2.2	0.0
35	0.0	0.0
36	0.0	0.0
37	0.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0

156.9 degrees BAND	DELTA JET	DELTA TOTL
17	-2.4	-2.4
18	-3.8	-3.8
19	-5.5	-5.5
20	-6.2	-6.2
21	-6.3	-6.3
22	-6.5	-6.5
23	-5.8	-5.8
24	-5.0	-5.0
25	-4.9	-4.9
26	-4.0	-4.0
27	-3.7	-3.7
28	-3.2	-3.2
29	-2.7	-2.6
30	-2.1	-1.1
31	-2.2	-0.2
32	-2.1	-0.1
33	-2.2	-0.1
34	-2.1	-0.1
35	0.0	0.0
36	0.0	0.0
37	0.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0

SIDELINE

Delta = Porous - Reference

50.9 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.4	-1.4
18	-2.2	-2.2
19	-1.9	-1.9
20	-2.2	-2.2
21	-2.7	-2.7
22	-3.2	-3.2
23	-3.4	-3.4
24	-2.8	-2.8
25	-3.5	-3.5
26	-3.9	-3.9
27	-3.4	-3.4
28	-2.5	-2.5
29	-2.0	-2.0
30	-1.9	-1.1
31	-1.9	-1.6
32	-1.8	-1.2
33	-1.8	-0.8
34	-1.8	-0.5
35	-2.0	-0.2
36	-2.0	-0.3
37	-1.9	-0.2
38	-1.3	0.0
39	-0.7	-0.1
40	0.0	0.0
53.1 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.5	-1.5
18	-2.1	-2.1
19	-1.8	-1.8
20	-2.3	-2.3
21	-2.8	-2.8
22	-3.4	-3.4
23	-3.4	-3.4
24	-2.9	-2.9
25	-3.5	-3.5
26	-3.9	-3.9
27	-3.6	-3.6
28	-2.7	-2.7
29	-2.2	-2.2
30	-2.1	-1.3
31	-2.0	-1.8
32	-2.0	-1.3
33	-2.0	-0.8
34	-2.0	-0.5
35	-2.1	-0.2
36	-2.1	-0.3
37	-2.0	-0.1
38	-1.5	0.0
39	-0.8	0.0
40	0.0	0.0
55.4 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.4	-1.4
18	-2.0	-2.0
19	-1.8	-1.8
20	-2.3	-2.3
21	-2.9	-2.9
22	-3.5	-3.5
23	-3.5	-3.5
24	-3.1	-3.1
25	-3.5	-3.5
26	-4.0	-4.0
27	-3.7	-3.7
28	-3.0	-3.0
29	-2.4	-2.4
30	-2.2	-1.4
31	-2.2	-1.9
32	-2.2	-1.4
33	-2.1	-1.0
34	-2.1	-0.6
35	-2.2	-0.3
36	-2.2	-0.4
37	-2.1	-0.2
38	-1.6	0.0
39	-0.9	-0.1
40	0.0	0.0

SIDELINE

57.8 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.4	-1.4
18	-1.9	-1.9
19	-1.7	-1.7
20	-2.5	-2.5
21	-3.0	-3.0
22	-3.6	-3.6
23	-3.5	-3.5
24	-3.2	-3.2
25	-3.4	-3.4
26	-4.1	-4.1
27	-3.8	-3.8
28	-3.3	-3.3
29	-2.6	-2.6
30	-2.4	-1.6
31	-2.4	-2.1
32	-2.3	-1.6
33	-2.3	-1.1
34	-2.3	-0.7
35	-2.4	-0.4
36	-2.4	-0.4
37	-2.2	-0.2
38	-1.7	-0.1
39	-1.0	0.0
40	0.0	0.0
60.5 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.4	-1.4
18	-1.9	-1.9
19	-1.7	-1.7
20	-2.5	-2.5
21	-3.1	-3.1
22	-3.9	-3.9
23	-3.5	-3.5
24	-3.3	-3.3
25	-3.4	-3.4
26	-4.2	-4.2
27	-3.9	-3.9
28	-3.5	-3.5
29	-2.8	-2.4
30	-2.6	-1.8
31	-2.6	-2.3
32	-2.5	-1.6
33	-2.5	-1.2
34	-2.5	-0.8
35	-2.5	-0.5
36	-2.5	-0.4
37	-2.4	-0.2
38	-1.9	0.0
39	-1.1	-0.1
40	0.0	0.0
63.4 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.4	-1.4
18	-1.9	-1.9
19	-1.8	-1.8
20	-2.4	-2.4
21	-3.0	-3.0
22	-3.6	-3.6
23	-3.5	-3.5
24	-3.3	-3.3
25	-3.4	-3.4
26	-4.2	-4.2
27	-3.8	-3.8
28	-3.6	-3.6
29	-2.9	-2.9
30	-2.6	-1.9
31	-2.7	-2.3
32	-2.5	-1.9
33	-2.6	-1.2
34	-2.6	-0.9
35	-2.6	-0.6
36	-2.6	-0.5
37	-2.5	-0.1
38	-2.0	-0.1
39	-1.3	-0.1
40	-0.6	0.0

66.4 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.3	-1.3
18	-1.9	-1.9
19	-1.8	-1.8
20	-2.4	-2.4
21	-2.9	-2.9
22	-3.4	-3.4
23	-3.4	-3.4
24	-3.2	-3.2
25	-3.3	-3.3
26	-4.0	-4.0
27	-3.7	-3.7
28	-3.6	-3.6
29	-3.1	-3.1
30	-2.7	-2.1
31	-2.7	-2.3
32	-2.6	-2.1
33	-2.6	-1.4
34	-2.7	-1.0
35	-2.8	-0.6
36	-2.8	-0.6
37	-2.6	-0.1
38	-2.2	0.0
39	-1.5	-0.1
40	-0.7	-0.1
69.7 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.3	-1.3
18	-1.8	-1.8
19	-2.0	-2.0
20	-2.4	-2.4
21	-2.7	-2.7
22	-3.0	-3.0
23	-3.3	-3.3
24	-3.1	-3.1
25	-3.3	-3.3
26	-3.8	-3.8
27	-3.6	-3.6
28	-3.7	-3.7
29	-3.2	-3.2
30	-2.8	-2.3
31	-2.7	-2.3
32	-2.7	-2.4
33	-2.7	-1.6
34	-2.7	-1.2
35	-3.0	-0.7
36	-2.9	-0.7
37	-2.7	-0.2
38	-2.2	-0.1
39	-1.7	-0.2
40	-0.8	0.0
73.1 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.2	-1.2
18	-1.8	-1.8
19	-1.9	-1.9
20	-2.3	-2.3
21	-2.7	-2.7
22	-2.8	-2.8
23	-3.2	-3.2
24	-3.1	-3.1
25	-3.3	-3.3
26	-3.6	-3.6
27	-3.5	-3.5
28	-3.7	-3.7
29	-3.3	-3.3
30	-2.9	-2.8
31	-2.7	-2.3
32	-2.8	-2.4
33	-2.8	-1.8
34	-2.8	-1.2
35	-3.0	-0.8
36	-3.0	-0.8
37	-2.8	-0.1
38	-2.3	-0.2
39	-1.7	-0.2
40	-0.8	0.0

76.8 degrees	DELTA	DELTA
BAND	**JET**	**TOTL**
17	-1.1	-1.1
18	-1.7	-1.7
19	-1.9	-1.9
20	-2.3	-2.3
21	-2.6	-2.6
22	-2.8	-2.8
23	-3.1	-3.1
24	-3.1	-3.1
25	-3.3	-3.3
26	-3.6	-3.6
27	-3.5	-3.5
28	-3.6	-3.6
29	-3.4	-3.4
30	-2.8	-2.8
31	-2.7	-2.4
32	-2.7	-2.4
33	-2.7	-1.8
34	-2.8	-1.0
35	-3.0	-0.9
36	-3.0	-0.8
37	-2.7	-0.1
38	-2.3	-0.2
39	-1.7	-0.2
40	-0.8	-0.1
80.6 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-0.9	-0.9
18	-1.8	-1.8
19	-1.9	-1.9
20	-2.2	-2.2
21	-2.5	-2.5
22	-2.7	-2.7
23	-3.1	-3.1
24	-2.9	-2.9
25	-3.2	-3.2
26	-3.4	-3.4
27	-3.5	-3.5
28	-3.7	-3.7
29	-3.3	-3.3
30	-2.9	-2.9
31	-2.7	-2.4
32	-2.8	-2.4
33	-2.7	-2.0
34	-2.7	-0.9
35	-3.0	-0.9
36	-3.0	-0.9
37	-2.7	0.0
38	-2.2	-0.2
39	-1.6	-0.2
40	-0.7	-0.1
84.6 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTAL**
17	-0.7	-0.7
18	-1.6	-1.6
19	-1.7	-1.7
20	-2.0	-2.0
21	-2.2	-2.2
22	-2.7	-2.7
23	-2.9	-2.9
24	-2.9	-2.9
25	-3.2	-3.2
26	-3.6	-3.6
27	-3.6	-3.6
28	-3.8	-3.8
29	-3.6	-3.6
30	-3.1	-3.1
31	-2.8	-2.9
32	-2.9	-2.7
33	-2.8	-2.5
34	-2.9	-1.2
35	-3.0	-1.9
36	-3.0	-1.1
37	-2.7	-0.1
38	-2.3	-0.3
39	-1.7	-0.2
40	-0.8	0.0

SIDELINE

88.6 degrees	DELTA	DELTA
BAND	JET	TOTAL
17	-0.6	-0.6
18	-1.5	-1.5
19	-1.6	-1.6
20	-1.8	-1.8
21	-2.2	-2.2
22	-2.8	-2.8
23	-2.8	-2.8
24	-3.0	-3.0
25	-3.2	-3.2
26	-3.7	-3.7
27	-3.6	-3.6
28	-3.9	-3.9
29	-3.7	-3.7
30	-3.3	-3.3
31	-2.9	-2.9
32	-2.9	-2.7
33	-2.9	-2.3
34	-2.9	-1.1
35	-3.1	-1.5
36	-3.0	-0.8
37	-2.8	-0.1
38	-2.3	-0.2
39	-1.8	-0.1
40	-0.9	0.0
92.8 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTAL**
17	-0.7	-0.7
18	-1.6	-1.6
19	-1.7	-1.7
20	-1.8	-1.8
21	-2.3	-2.3
22	-2.8	-2.8
23	-2.8	-2.8
24	-3.0	-3.0
25	-3.2	-3.2
26	-3.8	-3.8
27	-3.7	-3.7
28	-3.8	-3.8
29	-3.6	-3.6
30	-3.2	-3.2
31	-2.9	-2.9
32	-2.9	-2.6
33	-2.8	-2.0
34	-2.9	-1.0
35	-3.0	-1.1
36	-3.0	-0.5
37	-2.8	0.0
38	-2.3	-0.2
39	-1.7	-0.1
40	-0.9	0.0
96.9 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTAL**
17	-0.9	-0.9
18	-1.7	-1.7
19	-1.8	-1.8
20	-1.9	-1.9
21	-2.5	-2.5
22	-2.8	-2.8
23	-2.8	-2.8
24	-3.0	-3.0
25	-3.2	-3.2
26	-3.8	-3.8
27	-3.8	-3.8
28	-3.8	-3.8
29	-3.6	-3.6
30	-3.1	-3.1
31	-2.8	-2.8
32	-2.8	-2.5
33	-2.9	-1.9
34	-2.9	-1.0
35	-3.1	-1.0
36	-3.0	-0.5
37	-2.8	-0.1
38	-2.3	-0.2
39	-1.7	-0.1
40	-0.9	0.0

SIDELINE

101.1 degrees BAND	DELTA JET	DELTA TOTL
17	-1.1	-1.1
18	-1.8	-1.8
19	-2.0	-2.0
20	-2.1	-2.1
21	-2.8	-2.8
22	-2.8	-2.8
23	-2.8	-2.8
24	-3.1	-3.1
25	-3.3	-3.3
26	-3.9	-3.9
27	-4.0	-4.0
28	-3.9	-3.9
29	-3.6	-3.6
30	-3.0	-3.0
31	-2.8	-2.8
32	-2.8	-2.5
33	-2.9	-1.8
34	-3.0	-1.0
35	-3.1	-0.9
36	-3.0	-0.5
37	-2.8	-0.1
38	-2.3	-0.1
39	-1.6	-0.1
40	-0.9	0.0

105.2 degrees BAND	DELTA JET	DELTA TOTL
17	-1.4	-1.4
18	-2.0	-2.0
19	-2.2	-2.2
20	-2.4	-2.4
21	-3.3	-3.3
22	-3.0	-3.0
23	-3.1	-3.1
24	-3.3	-3.3
25	-3.6	-3.6
26	-4.3	-4.3
27	-4.3	-4.3
28	-4.2	-4.2
29	-3.8	-3.8
30	-3.2	-3.2
31	-3.0	-3.0
32	-3.0	-2.7
33	-3.1	-2.0
34	-3.2	-1.1
35	-3.2	-0.8
36	-3.2	-0.4
37	-3.0	0.0
38	-2.5	-0.2
39	-1.8	-0.1
40	-0.9	0.0

109.2 degrees BAND	DELTA JET	DELTA TOTL
17	-1.6	-1.6
18	-2.3	-2.3
19	-2.5	-2.5
20	-2.8	-2.8
21	-3.7	-3.7
22	-3.3	-3.3
23	-3.5	-3.5
24	-3.5	-3.5
25	-3.9	-3.9
26	-4.6	-4.6
27	-4.6	-4.6
28	-4.5	-4.5
29	-4.0	-4.0
30	-3.4	-3.4
31	-3.2	-3.2
32	-3.2	-3.0
33	-3.3	-2.5
34	-3.4	-1.6
35	-3.4	-1.0
36	-3.4	-0.4
37	-3.1	0.0
38	-2.6	-0.1
39	-1.9	-0.1
40	-1.1	-0.1

113.0 degrees BAND	DELTA JET	DELTA TOTL
17	-1.8	-1.8
18	-2.6	-2.6
19	-2.8	-2.8
20	-3.3	-3.3
21	-4.3	-4.3
22	-3.7	-3.7
23	-3.9	-3.9
24	-3.8	-3.8
25	-4.2	-4.2
26	-4.8	-4.8
27	-4.8	-4.8
28	-4.8	-4.8
29	-4.3	-4.3
30	-3.6	-3.6
31	-3.3	-3.3
32	-3.4	-3.3
33	-3.4	-3.3
34	-3.5	-2.7
35	-3.5	-1.8
36	-3.6	-0.4
37	-3.2	0.0
38	-2.8	-0.2
39	-2.1	-0.1
40	-1.3	-0.1
116.7 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.0	-2.0
18	-2.8	-2.8
19	-3.2	-3.2
20	-3.8	-3.8
21	-4.8	-4.8
22	-4.3	-4.3
23	-4.3	-4.3
24	-4.1	-4.1
25	-4.5	-4.5
26	-4.9	-4.9
27	-4.9	-4.9
28	-4.9	-4.9
29	-4.6	-4.6
30	-3.7	-3.7
31	-3.4	-3.4
32	-3.5	-3.5
33	-3.5	-3.6
34	-3.6	-3.5
35	-3.7	-3.0
36	-3.7	-0.5
37	-3.3	-0.1
38	-2.9	-0.2
39	-2.2	-0.1
40	-1.4	0.0
120.3 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.2	-2.2
18	-3.0	-3.0
19	-3.5	-3.5
20	-4.3	-4.3
21	-5.3	-5.3
22	-4.9	-4.9
23	-4.8	-4.8
24	-4.5	-4.5
25	-4.8	-4.8
26	-5.2	-5.2
27	-5.1	-5.1
28	-5.1	-5.1
29	-4.8	-4.8
30	-3.8	-3.8
31	-3.5	-3.5
32	-3.7	-3.7
33	-3.7	-3.7
34	-3.6	-3.6
35	-3.9	-3.5
36	-3.8	-0.5
37	-3.5	-0.1
38	-3.1	-0.2
39	-2.4	-0.2
40	-1.5	0.0

SIDELINE

123.6 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-2.2	-2.2
18	-3.1	-3.1
19	-3.5	-3.5
20	-4.6	-4.6
21	-5.8	-5.8
22	-5.7	-5.7
23	-5.6	-5.6
24	-5.2	-5.2
25	-5.3	-5.3
26	-5.5	-5.5
27	-5.3	-5.3
28	-5.3	-5.3
29	-5.0	-5.0
30	-3.9	-3.9
31	-3.5	-3.5
32	-3.7	-3.7
33	-3.5	-3.5
34	-3.5	-3.5
35	-3.6	-3.2
36	-3.7	-0.5
37	-3.3	-0.1
38	-2.9	-0.2
39	-2.3	-0.1
40	-1.4	0.0
126.7 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.2	-2.2
18	-3.1	-3.1
19	-3.6	-3.6
20	-5.0	-5.0
21	-6.3	-6.3
22	-6.6	-6.6
23	-6.4	-6.4
24	-5.9	-5.9
25	-5.9	-5.9
26	-5.9	-5.9
27	-5.5	-5.5
28	-5.5	-5.5
29	-5.1	-5.1
30	-4.0	-4.0
31	-3.4	-3.4
32	-3.6	-3.6
33	-3.2	-3.2
34	-3.2	-3.2
35	-3.5	-2.5
36	-3.5	-0.5
37	-3.2	-0.1
38	-2.7	-0.2
39	-2.1	-0.1
40	-1.1	0.0
129.6 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.2	-2.2
18	-3.2	-3.2
19	-3.7	-3.7
20	-5.2	-5.2
21	-6.6	-6.6
22	-7.3	-7.3
23	-7.1	-7.1
24	-6.6	-6.6
25	-6.5	-6.5
26	-6.1	-6.1
27	-5.6	-5.6
28	-5.7	-5.7
29	-5.2	-5.2
30	-4.1	-4.1
31	-3.4	-3.4
32	-3.5	-3.5
33	-3.1	-3.1
34	-3.1	-3.1
35	-3.4	-1.8
36	-3.4	-0.4
37	-3.1	0.0
38	-2.6	-0.1
39	-2.0	-0.1
40	-0.5	0.0

SIDELINE

132.3 degrees BAND	DELTA JET	DELTA TOTL
17	-2.1	-2.1
18	-3.1	-3.1
19	-3.6	-3.6
20	-5.3	-5.3
21	-6.8	-6.8
22	-7.6	-7.6
23	-7.5	-7.5
24	-7.0	-7.0
25	-6.9	-6.9
26	-6.5	-6.5
27	-6.0	-6.0
28	-6.0	-6.0
29	-5.5	-5.5
30	-4.4	-4.4
31	-3.7	-3.7
32	-3.6	-3.6
33	-3.0	-3.0
34	-3.1	-3.1
35	-3.3	-1.3
36	-3.3	-0.3
37	-3.0	-0.1
38	-2.5	-0.1
39	-1.9	-0.1
40	-0.1	0.0
134.8 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-2.1	-2.1
18	-3.1	-3.1
19	-3.5	-3.5
20	-5.2	-5.2
21	-6.9	-6.9
22	-7.9	-7.9
23	-7.9	-7.9
24	-7.3	-7.3
25	-7.2	-7.2
26	-6.8	-6.8
27	-6.5	-6.5
28	-6.5	-6.5
29	-5.9	-5.9
30	-4.7	-4.7
31	-4.0	-4.0
32	-3.8	-3.8
33	-3.0	-3.0
34	-3.0	-3.1
35	-3.3	-0.8
36	-3.2	-0.2
37	-3.0	-0.1
38	-2.5	0.0
39	-1.8	0.0
40	0.0	0.0
137.2 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTAL**
17	-2.1	-2.1
18	-3.1	-3.1
19	-3.5	-3.5
20	-5.2	-5.2
21	-6.9	-6.9
22	-8.1	-8.1
23	-8.2	-8.2
24	-7.7	-7.7
25	-7.5	-7.5
26	-7.1	-7.1
27	-6.8	-6.8
28	-6.9	-6.9
29	-6.3	-6.3
30	-5.0	-5.0
31	-4.2	-4.2
32	-3.9	-3.9
33	-3.0	-3.0
34	-3.0	-2.8
35	-3.3	-0.5
36	-3.2	-0.2
37	-3.0	-0.1
38	-2.5	0.0
39	-1.7	0.0
40	0.0	0.0

139.4 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-2.0	-2.0
18	-3.0	-3.0
19	-3.4	-3.4
20	-5.1	-5.1
21	-7.0	-7.0
22	-8.3	-8.3
23	-8.5	-8.5
24	-8.0	-8.0
25	-7.8	-7.8
26	-7.5	-7.5
27	-7.2	-7.2
28	-7.3	-7.3
29	-6.6	-6.6
30	-5.4	-5.4
31	-4.6	-4.6
32	-4.1	-4.1
33	-2.9	-2.9
34	-3.0	-2.2
35	-3.3	-0.3
36	-3.1	-0.1
37	-2.9	0.0
38	-2.4	0.0
39	-1.4	0.0
40	0.0	0.0
141.4 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.9	-1.9
18	-2.9	-2.9
19	-3.3	-3.3
20	-5.0	-5.0
21	-7.0	-7.0
22	-8.5	-8.5
23	-8.7	-8.7
24	-8.2	-8.2
25	-8.1	-8.1
26	-7.7	-7.7
27	-7.6	-7.6
28	-7.7	-7.7
29	-7.1	-7.1
30	-5.7	-5.7
31	-4.9	-4.9
32	-4.4	-4.4
33	-3.1	-3.1
34	-3.2	-1.4
35	-3.4	-0.3
36	-3.3	0.0
37	-3.1	0.0
38	-2.6	-0.1
39	0.0	0.0
40	0.0	0.0
143.2 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.8	-1.8
18	-2.8	-2.8
19	-3.2	-3.2
20	-4.9	-4.9
21	-6.9	-6.9
22	-8.5	-8.5
23	-8.8	-8.8
24	-8.3	-8.3
25	-8.4	-8.4
26	-7.9	-7.9
27	-8.0	-8.0
28	-8.1	-8.1
29	-7.5	-7.5
30	-6.1	-6.1
31	-5.4	-5.4
32	-4.8	-4.8
33	-3.4	-3.4
34	-3.5	-1.4
35	-3.6	-0.2
36	-3.6	0.0
37	-3.4	-0.1
38	-2.9	0.0
39	0.0	0.0
40	0.0	0.0

145.0 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.7	-1.7
18	-2.7	-2.7
19	-3.1	-3.1
20	-4.7	-4.7
21	-6.8	-6.8
22	-8.6	-8.6
23	-8.9	-8.9
24	-8.4	-8.4
25	-8.7	-8.7
26	-8.2	-8.2
27	-8.3	-8.3
28	-8.4	-8.4
29	-7.9	-7.9
30	-6.6	-6.6
31	-5.9	-5.9
32	-5.1	-5.1
33	-3.7	-3.7
34	-3.8	-1.5
35	-3.9	-0.3
36	-3.9	0.0
37	-3.7	0.0
38	-3.2	-0.1
39	0.0	0.0
40	0.0	0.0
146.6 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.7	-1.7
18	-2.7	-2.7
19	-3.1	-3.1
20	-4.7	-4.7
21	-6.7	-6.7
22	-8.6	-8.6
23	-8.9	-8.9
24	-8.5	-8.5
25	-9.0	-9.0
26	-8.4	-8.4
27	-8.7	-8.7
28	-8.8	-8.8
29	-8.3	-8.3
30	-7.0	-7.0
31	-6.3	-6.3
32	-5.4	-5.4
33	-3.9	-3.9
34	-4.1	-1.5
35	-4.2	-0.3
36	-4.1	0.0
37	-3.9	0.0
38	-3.4	-0.1
39	0.0	0.0
40	0.0	0.0
148.1 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.6	-1.6
18	-2.7	-2.7
19	-3.0	-3.0
20	-4.6	-4.6
21	-6.7	-6.7
22	-8.7	-8.7
23	-9.0	-9.0
24	-8.6	-8.6
25	-9.2	-9.2
26	-8.5	-8.5
27	-9.0	-9.0
28	-9.1	-9.1
29	-8.6	-8.6
30	-7.3	-7.3
31	-6.6	-6.6
32	-5.7	-5.7
33	-4.1	-4.1
34	-4.3	-1.4
35	-4.4	-0.3
36	-4.3	0.0
37	-4.1	0.0
38	-3.6	0.0
39	0.0	0.0
40	0.0	0.0

149.4 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.6	-1.6
18	-2.5	-2.5
19	-2.9	-2.9
20	-4.4	-4.4
21	-6.6	-6.6
22	-8.7	-8.7
23	-9.1	-9.1
24	-8.7	-8.7
25	-9.4	-9.4
26	-8.7	-8.7
27	-9.2	-9.2
28	-9.4	-9.4
29	-8.9	-8.9
30	-7.6	-7.6
31	-7.0	-7.0
32	-6.0	-6.0
33	-4.3	-3.6
34	-4.5	-1.3
35	-4.6	-0.3
36	-4.5	0.0
37	-4.3	0.0
38	-3.2	-0.1
39	0.0	0.0
40	0.0	0.0
150.7 degrees	DELTA	DELTA
BAND	JET	TOTAL
17	-1.6	-1.6
18	-2.5	-2.5
19	-2.9	-2.9
20	-4.4	-4.4
21	-6.6	-6.6
22	-8.7	-8.7
23	-9.1	-9.1
24	-8.7	-8.7
25	-9.6	-9.6
26	-8.8	-8.8
27	-9.5	-9.5
28	-9.6	-9.6
29	-9.1	-9.1
30	-7.9	-7.9
31	-7.3	-7.3
32	-6.3	-6.3
33	-4.6	-3.7
34	-4.7	-1.3
35	-4.9	-0.3
36	-4.8	0.0
37	-4.6	0.0
38	-2.2	-0.1
39	0.0	0.0
40	0.0	0.0
151.9 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.6	-1.6
18	-2.5	-2.5
19	-2.9	-2.9
20	-4.3	-4.3
21	-6.5	-6.5
22	-8.7	-8.7
23	-9.1	-9.1
24	-8.7	-8.7
25	-9.7	-9.7
26	-8.9	-8.9
27	-9.6	-9.6
28	-9.7	-9.7
29	-9.2	-9.2
30	-8.1	-8.1
31	-7.4	-7.4
32	-6.4	-6.4
33	-4.7	-3.9
34	-4.9	-1.3
35	-5.0	-0.3
36	-4.9	0.0
37	-4.7	0.0
38	-1.2	-0.1
39	0.0	0.0
40	0.0	0.0

153.0 degrees	DELTA	DELTA
BAND	JET	TOTL
17	-1.5	-1.5
18	-2.5	-2.5
19	-2.8	-2.8
20	-4.3	-4.3
21	-6.5	-6.5
22	-8.7	-8.7
23	-9.1	-9.1
24	-8.7	-8.7
25	-9.9	-9.9
26	-9.0	-9.0
27	-9.8	-9.8
28	-10.0	-10.0
29	-9.5	-9.5
30	-8.3	-8.3
31	-7.7	-7.7
32	-6.7	-6.7
33	-5.1	-4.4
34	-5.2	-1.4
35	-5.3	-0.2
36	-5.2	-0.1
37	-5.0	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0
154.1 degrees	**DELTA**	**DELTA**
BAND	**JET**	**TOTL**
17	-1.5	-1.5
18	-2.5	-2.5
19	-2.8	-2.8
20	-4.3	-4.3
21	-6.4	-6.4
22	-8.7	-8.7
23	-9.1	-9.1
24	-8.7	-8.7
25	-10.0	-10.0
26	-9.1	-9.1
27	-9.9	-9.9
28	-10.1	-10.1
29	-9.6	-9.6
30	-8.5	-8.5
31	-7.8	-7.8
32	-6.9	-6.8
33	-5.2	-4.6
34	-5.4	-1.4
35	-5.5	-0.3
36	-5.4	0.0
37	-5.2	0.0
38	0.0	0.0
39	0.0	0.0
40	0.0	0.0

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 2000	Contractor Report

4. TITLE AND SUBTITLE	5. FUNDING NUMBERS
Small Engine Technology (SET)—Task 13 ANOPP Noise Prediction for Small Engines *Jet Noise Prediction Module, Wing Shielding Module, and System Studies Results*	WU 538-03-13-01 NAS3-27483, Task 13
6. AUTHOR(S) Lysbeth Lieber	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AlliedSignal Engines and Systems 111 S. 34th Street P.O. Box 52180 Phoenix, AZ 85072-2180	8. PERFORMING ORGANIZATION REPORT NUMBER L-21-10786
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) National Aeronautics and Space Administration Langley Research Center Hampton, VA 23681-2199	10. SPONSORING/MONITORING AGENCY REPORT NUMBER NASA/CR-2000-209706

11. SUPPLEMENTARY NOTES

Contracting Officer: Linda M. Kendrick Mail Code 500-305 NASA-Glenn Research Center. This report was prepared for Langley under Task 13 of NASA Contract NAS3-27483. Langley Task Monitor: Robert Golub.

12a. DISTRIBUTION/AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Unclassified-Unlimited Subject Category 71 Distribution: Standard Availability: NASA CASI (301) 621-0390	

13. ABSTRACT (*Maximum 200 words*)

This Final Report has been prepared by AlliedSignal Engines and Systems, Phoenix, Arizona, documenting work performed during the period May 1997 through June 1999, under the Small Engines Technology Program, Contract No. NAS3-27483, Task Order 13, ANOPP Noise Prediction for Small Engines. The report specifically covers the work performed under Subtasks 4, 5 and 6. Subtask 4 describes the application of a semi-empirical procedure for jet noise prediction, subtask 5 describes the development of a procedure to predict the effects of wing shielding, and subtask 6 describes the results of system studies of the benefits of the new noise technology on business and regional aircraft.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Small Engine Technology, Noise Prediction, Computer Model	177
	16. PRICE CODE A09

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z-39-18
298-102